$3 A YEAR

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · MAY 16, 1960

Have you heard of the wonderful one-hoss shay,
That was built in such a reliable way
It ran a hundred years to a day . . .

SEE HORIZONS

a manual of **R** *eliability* A 32-PAGE SPECIAL REPORT

DESIGN SHOW ISSUE

HAVE YOU TAKEN SIDES IN THE BELT DRIVE REVOLUTION?

The change from Multi-V to Multi-Wedge is revolutionizing belt drives. A simple change in shape gives the Wedge Belt greater efficiency. Thus the number of belts can be less, diameters can be reduced 30 to 50% and center distances cut 20% for the same transmitted horsepower. In fact, Multi-Wedge drives result in initial savings up to 20%.

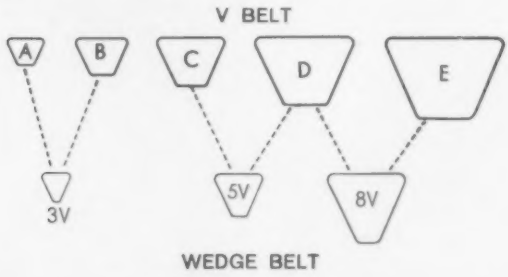
Because of this potential saving, it's to industry's advantage to design Wedge-Belts into new equipment as soon as convenient. But Worthington will supply complete requirements in both Multi-V and Multi-Wedge drives until the latter has completely taken over.

Are you worried about interchangeability of brands? Frankly, five out of the eight leading drive manufacturers now offer Multi-Wedge, as well as the Multi-V drives. And so far, all Multi-Wedge drives are offered in the same belt and sheave sizes.

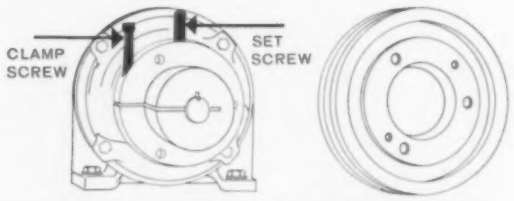
There is, however, an important reason for preferring the Worthington Multi-Wedge drive. Worthington makes the QD (Quick Detachable) sheave—the industry's largest seller—in the complete range of Multi-Wedge standardized dimensions. This sheave, with its two Golden Screws, appeals to plant operators because of its positive locking arrangement—easy on . . . easy off . . . always tight.

For Multi-Wedge drives, Worthington maintains a large stock of its QD sheaves and Worthington-Goodyear Wedge belts from coast to coast. For information call your Worthington distributor listed in the yellow pages of your phone book. Or write Worthington Corporation, Section 79-28, Oil City, Pennsylvania.

The cord layer near the top of either belt carries the load. This layer is, however, only efficient in the portion supported by side walls (red areas). Because more of its top section is over the side walls, the Wedge belt is more efficient than a V belt.



Because the smaller Wedge belt does more work, the number of sizes have been reduced without loss of flexibility. The new Wedge belts are available in three standard sections: 3V, 5V and 8V. Stock 3V and 5V sheaves cover horsepower ranges through 200 hp. Made to order 8V sheaves will be used for 200 to 2,000 hp. requirements.



Worthington QD sheaves are preferable for Multi-Wedge drives. The clamp screw simplifies installation, assures permanent alignment, and makes it possible to use a set screw without causing hub distortion that might cause eccentric runout. The set screw prevents "key drift" by locking the key securely in place. You install QD sheaves easily—one part at a time. If change in speed is required, you simply install another sheave on the hub which remains anchored to the shaft.

WORTHINGTON

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

May 16, 1960 Vol. 31, No. 20

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the Design Show

New steels are born at Armco

See How Armco Special Steels Are Used
To Improve Design and Reduce Costs

Armco exhibit in Booths 725-726 will feature proved applications of Armco 17-4 PH Stainless Steel, Armco ALUMINIZED STEEL and present outstanding new Armco developments in zinc-coated steel.

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INTERESTING TO NOTE

On Our Cover–The "one-hoss shay" of grandfather's day was built so it couldn't break down, but instead would wear out after a hundred years. Oliver Wendell Holmes, in his famous poem (p 63), says "it was built in such a *logical* way." With modern usage, we would be inclined to say it was built in a *reliable* way. We have taken poetic license to make this change on our cover.

Today we can make this change with impunity. But one hundred years ago, when "reliable" first came into popular usage, there probably would have been a loud protest from England. British writers objected to the word; they disliked its irregular form, and stigmatized it as an "Americanism."

Packaged Soldiers

Our first encounter with roller chains probably occurred as youngsters when our pants leg got caught in the chain of our bicycle. Actually roller-chain driving mechanisms were introduced in this country by Oliver Evens, when he designed the first automated mill in 1799. As the article on page 109 shows, roller chains are still a valuable aid to the designer.

When chain was first produced, it was made in the form of mail and used strictly by fighting knights. Such mail was usually hand-manufactured by an armorer, who welded or riveted each chain link around the next. These crude fastenings were not strong enough to prevent holes from forming in the elaborate metal uniforms, but in all, chain-mail served its purpose. It wasn't until the 14th century that the power of missiles hurled by crossbows forced the romantic knights of yore to turn in their armor. But before yielding to the new weapons, knights first tried wearing a coat of chain-mail under an iron plate contoured to protect the breast and back. Special hinges were designed to permit free movement of the limbs. Since the fighter was covered with metal from head to toe, a coat-of-arms on his shield acted as a means of identification. The weight of the armor was so enormous however, that many knights died of over-exertion before coming within range of the enemy's sword.

When Submarines Were Unreliable

Although the trial-and-error procedure may be satisfactory for some products, there are a great many cases when a more reliable method is needed. In fact the very term "reliability" has been adopted for a new function of engineering (p 65). In the design of a missile, it is totally unfeasible to try various components until, by chance, a workable combination is achieved. The process takes too long and costs too much. So the principles of probability are used instead.

continued, next page

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It's interesting that in and around the various missile manufacturing and testing centers, the effort to promote reliability takes on many aspects of a home-coming football game—matchcovers contain the word in bold letters, so do posters and stickers. If the defense industry had been as interested in reliability a century ago as it is today, the history of the Civil War might read differently. In the early stages of the fighting, the Union Navy was quite successful against Southern shore batteries. According to Bruce Catton's *Grant Moves South*, Union gunboats played a most important part in Grant's success in the capture of Fort Donelson. The Confederency decided that to counterattack, submarines should be used against the Union Navy.

The first Confederate submarine met with disaster at the very outset. Called the Pioneer, it was 20 ft long, 3 ft wide and had a crew of three. This sub set out to meet Farragut's Gulf blockade, but sank with its crew during a test dive. The experience of the Pioneer taught its builders that water compartments at either end would provide better trim and ballast. This was tried in the Hunley, named after one of the builders. The Hunley was bigger than the Pioneer but still not very reliable. Four times in succession the ship went out of control and sank; on each occasion a crew of eight was lost. The fifth crew lasted a little longer. In 1864, the Hunley torpedoed the USS Housatonic, but was trapped in the hole it opened in the Housatonic's hull and sank embedded in its victim.

A century ago, questionable designs were tested at the risk of human lives. Today, the responsibility for a reliable product rests with the designer; and close inspection and quality control during inspection have replaced trial and error.

—Benedict A. Leerburger, Jr.

Confederate Museum, Richmond, Va

Chapman's Painting of The Hunley.

Jack Meyer, Product Engineering's Los Angeles editor, died in a California automobile accident on April 27. It was Jack's resourcefulness and faithful service that did much in the past three years to keep our readers abreast of the fast-moving technological developments on the West Coast.

Before joining us, Jack had been with Brown Instrument Div of Minneapolis-Honeywell, and with Potter Aero Co. He was an alumnus of Cornell University and later studied extension teaching at Temple College.

A native of Brooklyn, NY, Jack was 37 years old at the time of his death. He is survived by his wife, Edith, and three children. We at Product Engineering will miss him too.

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Winners of First Annual Awards Program**
Drawings and descriptions of all winning entries in PRODUCT ENGINEERING'S Master Design Awards program.

. . . **Epoxy Parts Cast by Centrifugal Force**
For quantities that don't justify the high tooling cost of injection molding, this method may be the answer.

. . . **Design Requirements for Bearings and Lubrication**
On-the-spot report presents new design equations, charts and concepts presented at ASLE's Cincinnati meeting.

. . . **Damping Properties of a Clad Aluminum**
High-strength aluminum alloys, when clad with pure aluminum, gain up to 20 times their capacity to damp vibrational energy.

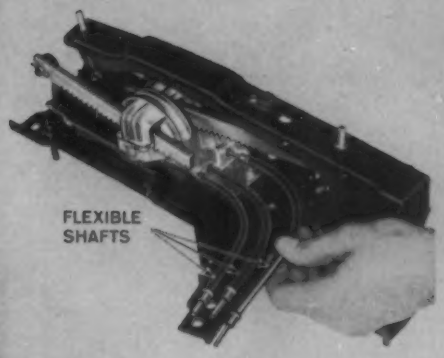
. . . **When Thin-wall Cylinders Carry the Load**
New equations give quick answers for stress and deflection caused by skirts or reinforcing rings.

. . . **Selecting the Right Solenoid**
A guide to designing with ac and dc solenoids of both linear and rotary types.

S. S. White

DRIVE AND CONTROL IDEAS FOR ENGINEERS

HEART OF THE POWER-SEAT MECHANISM... Two slave units, on the left and right sides of seat, are driven by flexible shafts to provide three-way motion. A *single* ¼-hp motor attached to a geared drive unit is the power source. Flexible shafts rotate at 1250 rpm, carry 9 in.-lbs. of torque at running load (three persons) and 15 in.-lbs. at full stall speed.



Flexible Shafts Solve Space Problems in Chrysler Power-Seat

Chrysler Corporation faced a design challenge in its power-operated seat adjuster. Six-way motion was called for: fore and aft, up and down, and tilt. Yet there was limited space under the seat for the mechanism. After much Chrysler testing and development, a design submitted by subcontractor Ferro Stamping Company was approved, utilizing flexible shafts.

According to Chrysler, the decision to go to flexible shafts was based on the following advantages:

1. SPACE ECONOMY..."flexible shafts provided means to transmit power from a single electric motor, without compromising seat design."

2. REDUCED STRESSES..."flexible shafts act as torsion bars to reduce motor armature stresses induced when the mechanism was stopped or stalled suddenly."

3. RELIABILITY..."not a single shaft fatigue failure reported from the field to date."

4. LOW COST..."flexible shafts definitely represented savings without sacrificing design advantages."

Investigate for yourself how flexible shafts can solve many of your design problems and at the same time reduce costs!

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IN FLEXIBLE SHAFTS

DEVELOPMENTS TO WATCH...

Petroleum lubricants developed for service to 600 F

Petroleum-base fluids that show "definite capability in hydraulic pump tests at 550 F and actuator tests at 600 F" have been developed at Penn State U's Petroleum Refining Lab under contract with the Air Force Nonmetallic Materials Laboratory, Materials Center, Wright Air Development Division. These are fluids derived from certain petroleum cuts, hydrogenated or acid-treated and then dewaxed, to produce materials with a lubricating ability "unsurpassed by any of the synthetically derived, high-temperature lubricants."

Also under study at the Petroleum Lab is the matter of long-term reliability of fluids. This is an exceedingly complex problem, involving not only the lubricant itself, but also the materials of system in which it will be used and the place it must be stored. First step in this study is a broad-scale investigation of chemical and physical properties and of the effects of various additives.

Synchros for computers

Synchro devices can perform mathematical functions, F. E. Hagen of Daystrom Transcoil told the Navy's Synchro Symposium. All that's needed is an additional variable-transformer component to accept the 3- or 4-wire electrical data and convert it into a mechanical signal. The variable-transformer component does this either by providing a null indication or by generating its own selective torque.

Furthermore, says Hagen, with a second synchro component containing primary windings capable of accepting the synchro electrical data, it is possible to advance or retract this data a given mechanical angle. Then, with the insertion of this differential data into the variable-transformer component, the mechanical output becomes the sum or the difference between two mechanical inputs.

This principle, Hagen says, can be carried out over a train of differential devices, within the limitations of their additive inaccuracies, for performing addition and subtraction of any number of mechanical inputs.

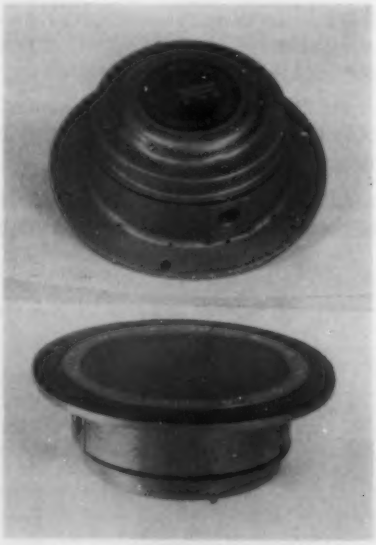
While recognizing the limitations of the linear synchro, Hagen believes none of its shortcomings are insurmountable. But with expected future improvements, he says, computer engineers can have a device of great reliability—a tool which at present is not available in any form.

British develop diaphragm level-switch

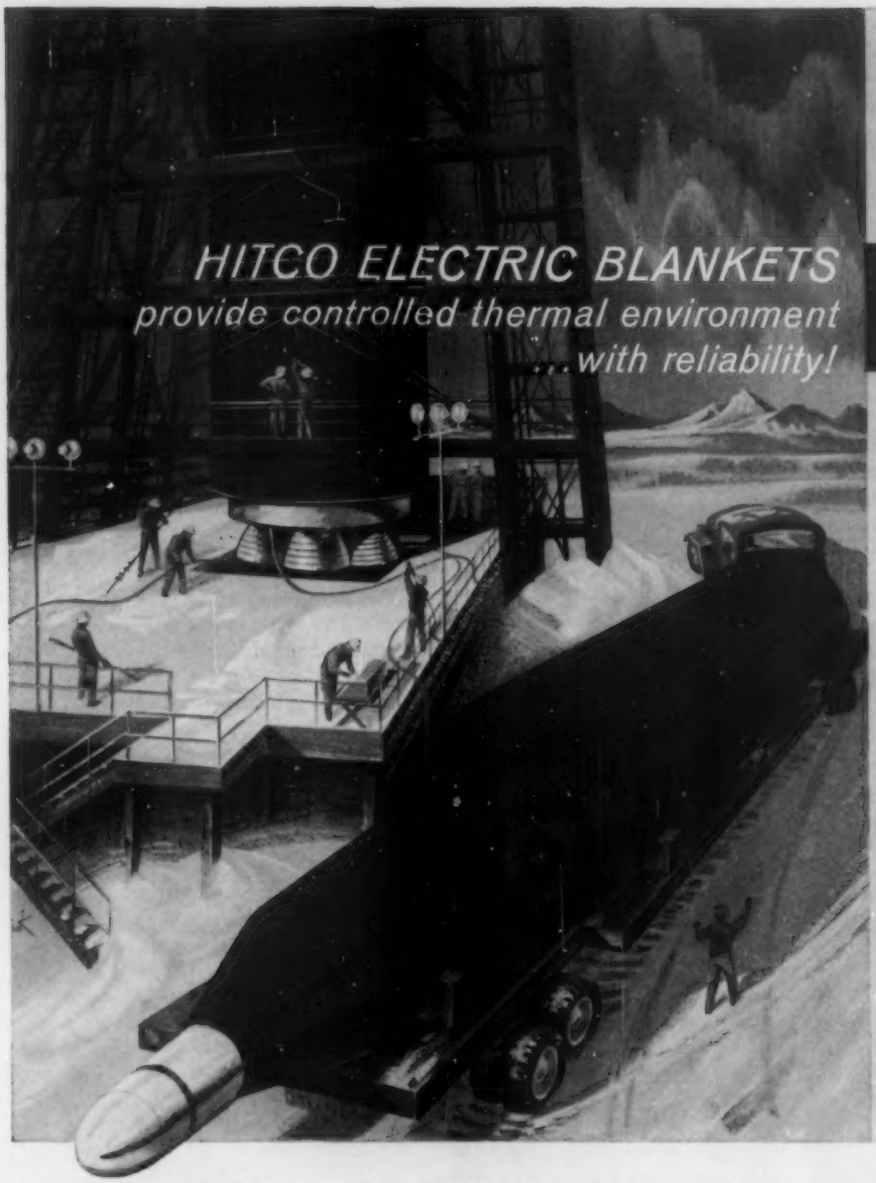
A pressure switch that can be used on weighing and blending devices, elevators, conveyors, and hoppers to indicate the height or level of granular or powdered mixtures has been developed by Londex Ltd., London SE 20.

It consists simply of a rubber diaphragm that serves as a sensing device as the material being monitored presses against it; and a 3-way terminal block with single-pole change-over snap-action contacts. This, in turn, can be connected to an indicating light, audible warning, or automatic metering device. Switching capacity (ac) is 3 amp at 440 v; 5 amp at 250 v. Dc ratings depend on the specific application.

Standard units will be 9 in. dia with a 6¼-in. diaphragm, priced in the $25-$30 range—half the cost of previous units.



DIAPHRAGM-OPERATED SWITCH has dust-proof brass housing, can be adjusted to compensate for changes in density of material being monitored.



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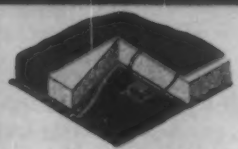
−65° to +2200°F



CUTAWAY VIEW. Shows Heating Element of HITCO Electric Blanket—sealed between cover and inner cover.

HONEYCOMB PANEL BRAZING. New HITCO Electric Blanket brazing technique provides faster, more reliable means of fabricating honeycomb structures.

INDUSTRIAL ELECTRIC HEATING ELEMENTS. HITCO Electric Heating Elements can be provided for a variety of industrial uses where a controlled thermal environment is required.

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Reduction in small-motor variety urged

A plea for reduction in the variety of small motors offered as standard equipment, and a strong warning of consequences if the number is not reduced, comes from E. D. Howell of International GE. Speaking at the 11th Annual Domestic Appliance Technical Conference, he pointed out that such a project is already underway in Europe, and will make possible competitive foreign manufacture of small motorized appliances ranging from vacuum cleaners to fans, even in low-volume quantities. The reduction could, he points out, help to make low-volume manufacture of such appliances economical in the US—or pose a threat to US manufacturers if a similar step is not taken here.

High-strength titanium oxide cermets produced

Metal-bonded titanium oxide parts with rupture strengths of 80,000 psi; and TiO-alumina-chromium compositions with strengths to 120,000 psi, have been produced at GE's Metallurgical Products Dept Lab, E. W. Golbier told the American Ceramic Society. Investigation of the lower oxides of titanium indicated that their semimetallic nature would make it easier for them to bond to metal than the normal oxides, and this turned out to be the case.

Also announced by Golbier: a fine-grained TiO-Al_2O_3 ceramic "of very high strength relative to conventional ceramics."

New thermoelements promise doubled efficiency

Thermoelectric modules for heating and cooling, "more than twice as efficient as any comparable devices," are being introduced by General Thermoelectric Corp, a new company owned by General Devices of Princeton, NJ, and Needco Cooling Semiconductors Ltd of Canada.

The new modules, to be called "Frigistors," are designed to take advantage of the Peltier effect in which heating or cooling will take place when an electric current is passed through a junction of two dissimilar metals or a semiconductor.

Secret of the efficiency of the new module, says General Thermoelectric, is its new quarternary semiconductor—antimony selenium bismuth telluride—in place of such binary compounds as bismuth telluride and lead telluride.

The new semiconductor is to be known as "Neelium," and thermoelements made from it will be in the form of cubes less than ¼ in. square. GTC does not, however, plan to sell the basic materials; but, rather, the complete Frigistor module, each of which will consist of 8 thermoelements, hooked up in series or parallel as desired. Price of the modules is to be $258 each.

New alloy does better than silver

A silver-indium-cadmium alloy that melts at about the same point as silver but shows considerably improved mechanical and thermal properties has been developed by Westinghouse Electric Corp.

Silver itself has a room-temperature tensile strength of 23,000 psi and a yield strength of 8000. The new alloy has a room-temperature ultimate tensile strength of 42,800. Its yield strength at room temperature is only about 10,500; but this figure holds surprisingly constant as the temperature rises. At 600 F it is still 9600 psi though ultimate tensile strength has dropped to 17,600. Room-temperature elongation of the new alloy is 67% at room temperature, as compared to 50 for silver; at 600 F elongation of the new alloy is 34%.

Since it is 80% silver, 15% indium, and 5% cadmium, the alloy is far from inexpensive. But it was developed for, and will likely first be used in, nuclear reactor control rods where it offers nuclear as well as metallurgical advantages.

Properties and fabrication methods for the alloy are described in Westinghouse Yankee Atomic Electric report YAEC-156, covering work done under contract AT (30-3) 222. —ARG

WHAT'S HAPPENING IN RESEARCH . . .

Superplastics on the way

New insulating materials that will "permit us to transport electricity at voltages 10 times those used today are now on the drawing boards of the polymer chemists," Dr Herman F. Mark of Brooklyn Polytechnic Institute told the American Chemical Society. And, he says, other insulating materials that will permit operation of motors at 800 to 1000 F are well along in development. Farther off, but definitely on their way, are plastics that will not melt even when red hot, and will not shatter even when hit by a bullet, Dr Mark predicts.

New papers from the farm

Paper from grasses, sweet peas and hibiscus? It's a real possibility, USDA's Agricultural Research Service reports.

The laboratory, which has been screening crops that might provide new types of pulp and textile fibers, reports that "representatives of the grass (including sorghum and bamboo), legume, and mallow (hibiscus and okra) families appear to be the most promising" thus far. Other possibilities: dogbane, milkweed, castor bean stalks.

USDA has developed a fiber-screening system for evaluating new plants and gives those listed above the highest ratings.

The screening program is continuing, with the goal of finding new uses for farm crops.

Rubbers that stop neutrons and X-rays

At least three rubbery materials have now been found to provide real protection against neutron and gamma radiation. That means it should be possible to design relatively lightweight, flexible shielding for instruments using radioactive isotopes, as well as for atom-powered space ships.

Rubber and rubberlike compounds have been under investigation for this purpose for some time now, and research is being reported.

A study of 116 elastomeric compounds by B F Goodrich researchers, for instance, showed butyl gum rubber stock to be the most promising neutron shield; while the likeliest material for shielding against both gamma and neutron radiation was a natural rubber containing titanium hydride.

This study was made several years ago, but has only now been declassified and released through OTS. It is available on microfilm from OTS, Dept of Commerce, Washhington 25, DC (BFG Project 17RB and 17RC reports, 23 p, $2.70).

Now, Goodrich reports further studies indicate that, for gamma radiation alone, one of the newer elastomeric plastics, polyurethane rubber, may be the best choice. It could be used on outdoor installations as well as indoor because it is said to have excellent weather resistance.

briefs . . .

Silicon varistors show better aging properties than standard copper-oxide types, says Bell Labs, and seem well able to perform their functions. In long-term tests at temperatures to 230 F, diffused-silicon units designed to serve as click-reducers ("eardrum protectors") in telephones showed "markedly less" aging than their copper-oxide counterparts.

As an index of metal purity, superconducting properties are "a valuable tool for evaluating sample perfection," says J. I. Budnick of IBM Research Lab. Very small amounts of gaseous impurities in tantalum, for instance, have pronounced effects on its nuclear magnetic resonance and other properties at ultralow temperatures; and this may well be used as an index of purity.

Chemical slide rule for solving problems involving solution concentrations and gas pressure-temperature-volume relations is being marketed by Dyna-Slide Co, 600 S. Michigan Ave, Chicago. Dyna-Slide says it will solve molarity problems and calculate the composition of the liquid and vapor phases in a mixture. Made of vinyl plastic, the Solution Concentration and Gas Law Slide Rule is 10½ by 3 in. Price: $10. —ARG

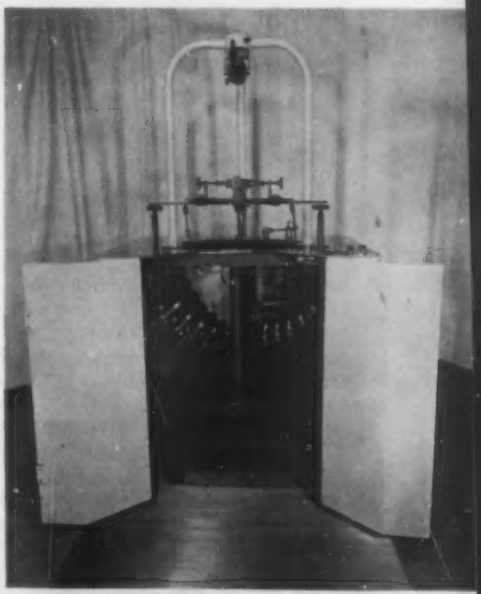
Camera calibration a la carte

An instrument that provides a symmetrical array of targets for calibration of technical cameras has been designed, developed and built by Photogrammetry Inc, 922 Burlington Drive, Silver Spring, Md.

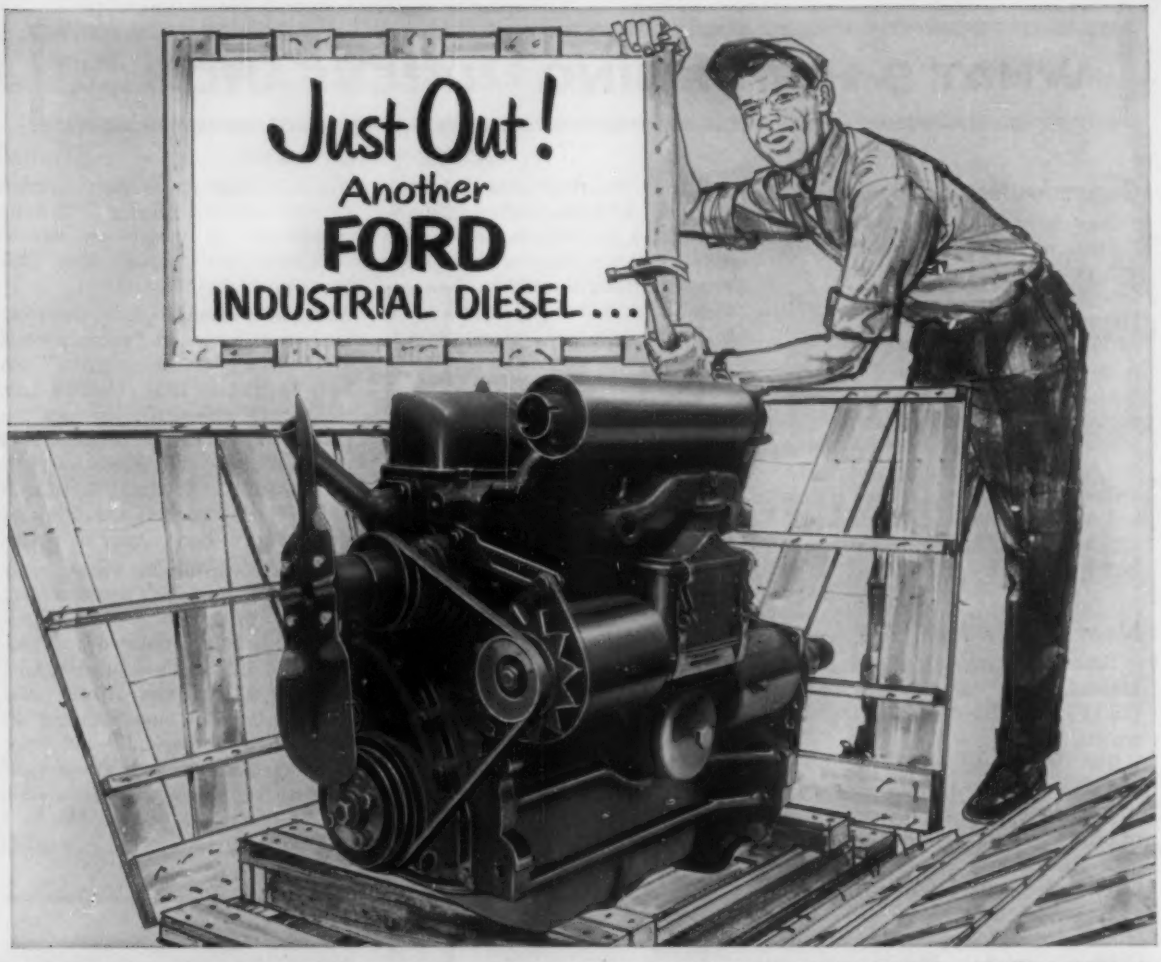
The targets, produced by 25 collimators arranged to form a cross, are photographed by the camera under test, and the negative is then measured for determinations of focal length, radial and tangential distortion and resolution, and other factors.

The unit will accommodate cameras with focal lengths from ½ to 12 in., has an illumination balance that is adjustable over the entire field, provides for automatically timed exposures, continuously variable from 2½ sec to 5 min., and has a number of other special features.

Originally designed for the Navy, the unit is now being introduced commercially in improved form. Price: $33,000, delivered, installed, and adjusted.



CAMERA CALIBRATOR is shown with doors open so collimator array can be seen. Crank raises or lowers camera stage to position the front nodal point of the camera lens at the intersection of the collimator axes.



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(and it's interchangeable with the 172-cu. in. gasoline engine)

To meet the growing demand for diesel power, Ford now offers a choice of three economical diesels—the highly efficient 172-, 220- and 330-cubic inch models.

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Bore and Stroke—Inches		3.9 x 3.6	3.94 x 4.52	3.94 x 4.52
Displacement—Cubic Inches		172	220	330
Brake Horsepower	Dynamometer	59 @ 2400	60 @ 2250	96 @ 2250
	80% Dyn. BHP	47 @ 2400	48 @ 2250	77 @ 2250
Torque	Dynamometer	140# @ 1200	151# @ 1600	236# @ 1600
	80% Dyn. BHP	112# @ 1200	121# @ 1600	189# @ 1600
Compression Ratio		16.5 to 1	16 to 1	16 to 1

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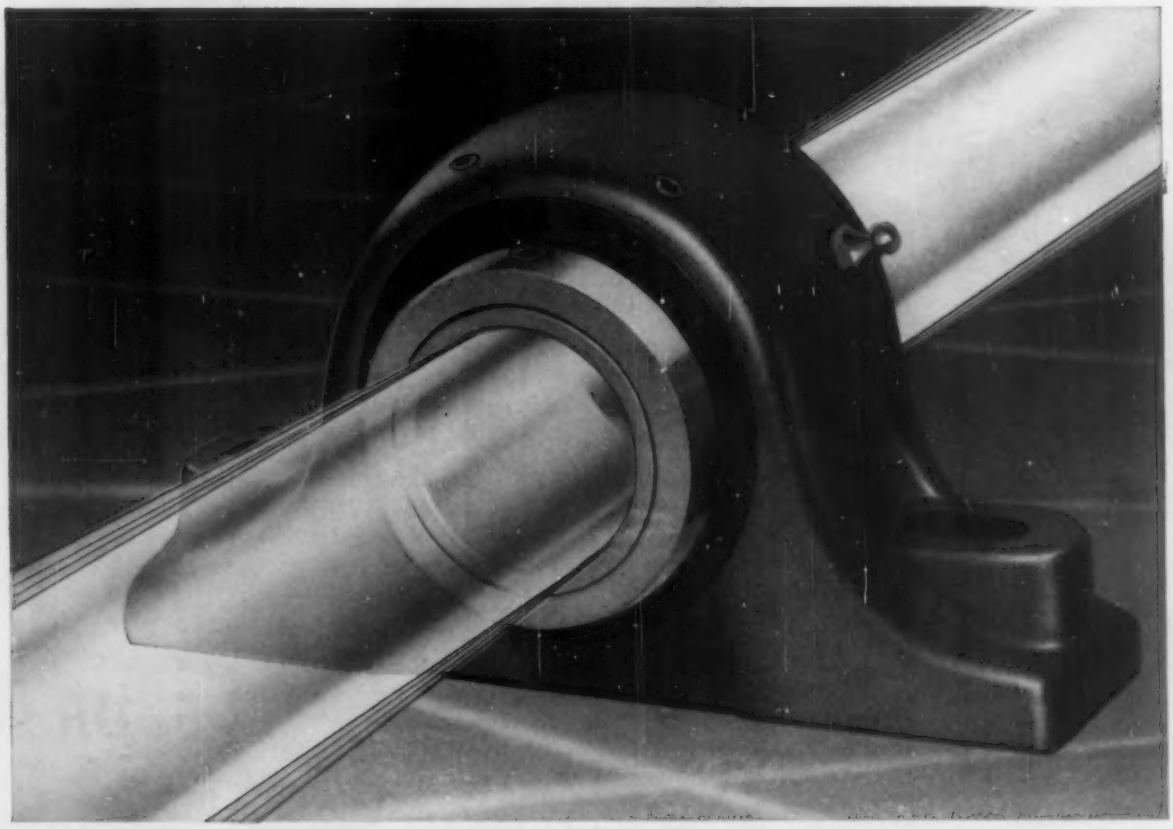

Link-Belt roller bearings compensate for misalignment of shafts and supports

Link-Belt Series 400 roller bearings have won a reputation as "the designer's choice." These self-aligning, double-row roller bearings compensate for inaccuracies in machining and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

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FROM WASHINGTON . . .

House Committee Recommends More Military R & D

Research money for the military may be increased over $300 million more than the Pentagon requested in its 1961 budget. That boost is what the powerful House Appropriations Committee has recommended.

If Congress okays the measure, $4.2 billion will be earmarked for research, development, test and evaluation in the new budget. The biggest chunk of the extra money—$208.6 million—will go to the Air Force for its satellite programs. Another $100 million will be added to the Navy's antisubmarine warfare program.

New development programs should be initiated under research, development, test and evaluation because of the added money. But, the legislators want close checks made on new basic research programs. In approving the new budget, the committee noted specifically that it wants the military "to carefully limit and control programs that involve the provision of new facilities and major items of equipment" in basic research projects.

Here is what the committee would dole out to individual services in the way of research money:

• **The Army asked for $1,041.7 million. The committee approved $1,041.2 million, a cut of $510,000. Last year it got $1,035.7 million. Some $36 million will be used by the Army to develop new aircraft and lay out guide lines for Army aircraft development over the next 10 years.** The biggest chunk of Army's research money will be pumped into its Nike-Zeus antimissile program, and its Pershing surface-to-surface solid-fueled missile.

• **The Navy would get $1,268.5 million, $99.5 million more than it requested in the 1961 budget. Navy received $1,015 in fiscal 1960. The largest chunk of Navy's research money will go to its Polaris program. Some $374 million is earmarked for this use.** The committee added $100 million to the $180 million that Navy requested for antisubmarine warfare, making a total of $280 million for this program.

Navy projects that will be pushed included the new Eagle missile, a defense against manned bombers. A long-range, subsonic aircraft, dubbed the Missileer, is under development by Navy to launch the Eagle missile. Navy's other new missile, the Typhoon, to provide greater shipboard air defense protection, will get part of the research money too.

• **The Air Force will get $1,542.6 million in R & D money under the committee's appropriation bill. This is an increase of $208.6 million. It compares with the $1,159.9 million it received in fiscal 1960.**

The committee voted an increase of $20.7 million for the development of the mobility capability of the Air Force's Minuteman program. Generally, the committee said adequate funds have been available to develop the missile itself. But the committee doesn't want any bottlenecks in the program's effectiveness through a shortage of mobile carriers to haul the missile around the country.

An increase of $54 million was added to the $121.4 million supplemental request the Air Force made in March for its three satellite programs—Discoverer, Midas, and Samos. This makes a total increase in funding for these projects in the 1961 budget of $175.4 million. **The committee approved, but did not increase the $75 million the Air Force requested for continued development work on a nuclear-powered aircraft.**

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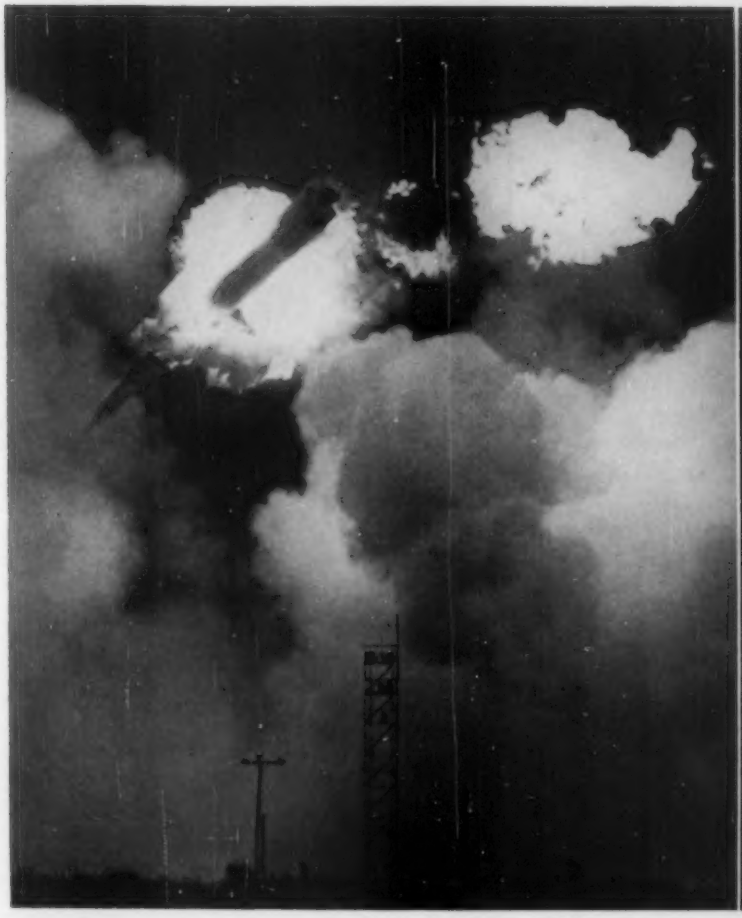


From Failures Come Better-engineered Missiles

Each malfunction tells the engineer—once the trouble is traced to a specific cause and a solution is found—a little more about the vastly complex vehicle he is designing. And in this special news feature a PRODUCT ENGINEERING editor tells what he found out from engineers at Cape Canaveral about missiles that aborted—and the technical clues that influenced better design.

NEW YORK—The banshee wail that followed early US missile failures has died away as more and more missiles and space probes go into intended trajectory and orbit. In a speech here, Murray Snyder, Assistant Secretary of Defense, summed it up: "The launching of a satellite, which two years ago made headlines through the world, does well today if it makes page one."

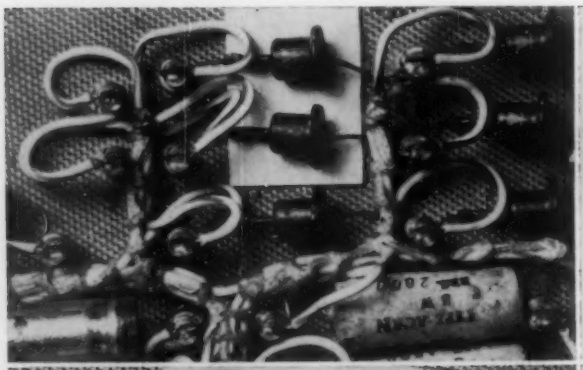
What now makes the successful launching commonplace? A decrease in component malfunctions and missile aborts.

Yes, missiles still fail, but these are usually the newer test vehicles. Of the older group, for example, Atlas has had 21 successful launchings; Titan, 8 successes in 12 tries with an R & D missile. Space probes seem to be leaving earth with regularity, so all indications point to more successes.

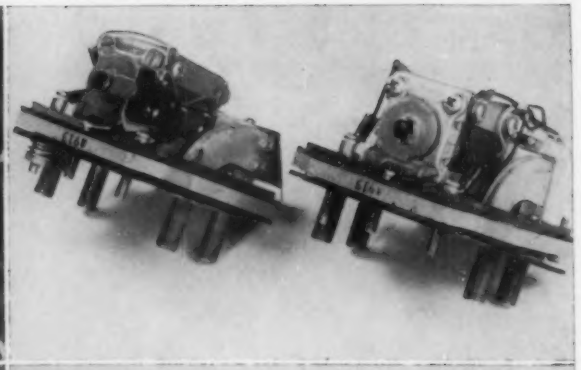
But why the failures early in a missile's developmental history? Remember your new car. Somethings always needed adjustment. And new aircraft, even after extensive flight and ground testing, aren't always perfect —for example, the Electra problems (*PE—May 2, p 15*). In addition, many of the early problems associated with a space program are caused by equipment not used with operational missiles—telemetering equipment, destruct packages, test gantries.

Often an abort gives more information than a successful flight. A case in point is the first Atlas test vehicle. It threw itself into exceedingly violent maneuvers, including a complete loop-the loop, while its propellant tanks

Some Causes of Missile Aborts . . .



. . . these diodes touched and shorted



. . . these relays vibrated and fired destruct

were still heavily loaded. Though G-forces experienced by the airframe far exceeded those ever met in normal flight, subsequent examination of high-speed motion pictures showed absolutely no rupture of the tank structure before the missile was destroyed by the range safety officer.

Outside professional engineering circles there had been some doubt that the Atlas "pressurized monocoque" structure could withstand the strains imposed during launch and powered flight. Not only did the malfunction clear up any doubt, but Convair was able to reduce skin thickness and save weight.

A missile is an incredibly complex mechanism. Some 40,000 parts must function together at peak performance through ignition, launching and powered flight. Malfunction of a single airborne part, or ground-support component before liftoff, will abort a flight or seriously degrade results. Now let's look at some examples.

RELIABILITY WAS THE ANSWER

Malfunction: On July 16, 1959, a Juno II space probe had to be destroyed after it left its pad at Cape Canaveral. At a thousand feet or so, when the missile toppled from its planned trajectory within the destruct area, it was blown up by the range safety officer.

Cause: Data recorded to the time of the destruct explosion spotted the probable trouble area—a power-supply failure. In the wreckage of the crash a 400-cycle power inverter was found with its diodes touching. They had shorted the unit, killing power to the guidance system. The cause was now known, but why, after many successful flights, had the inverter suddenly failed?

At the Army Ordnance Missile Command (AOMC), Huntsville, Ala, the Systems Analysis and Reliability Group thought they had the answer. In fact, this group had predicted the possibility of such a failure months before when qualification-level reliability testing showed that, under certain conditions, diodes in the 400-cycle inverter could short. Tests varied environmental conditions.

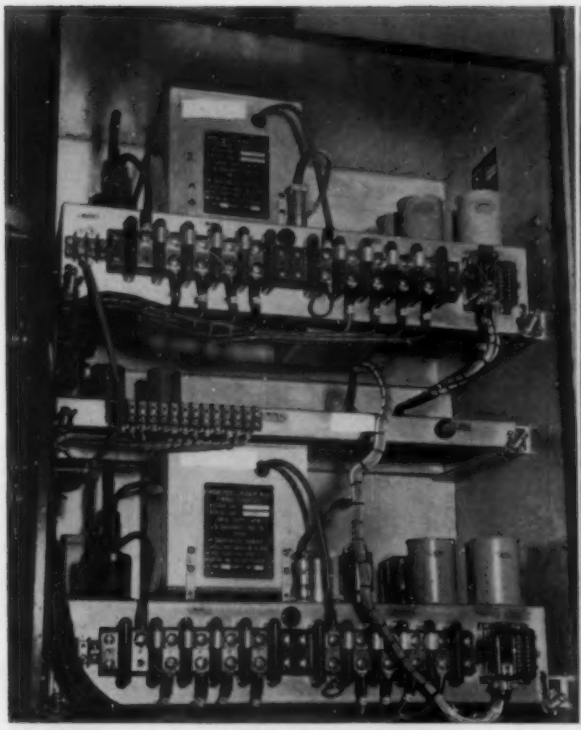
Solution: Inverters already in the field were fitted with plastic sleeves over the diodes to avoid shorting; and all new inverters are being potted.

DESTROYED BY SAFETY CIRCUIT

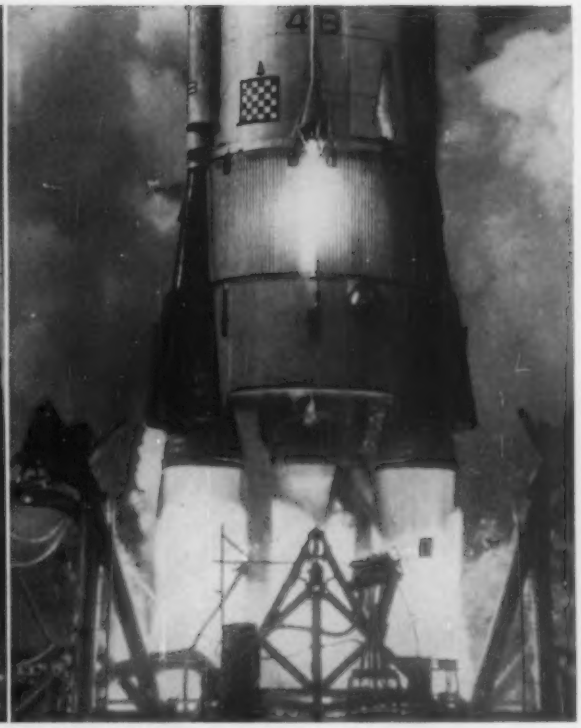
Malfunction: After four successful Martin Titan "A" missiles had flown, the first of the B series blew up on the pad at Cape Canaveral. Ignition of the engines had been normal but the missile started its liftoff before the 4-sec hold period for instrument check was completed.

Cause: The 4-sec holddown for instrument check is programed into the blockhouse sequencer and constitutes a safety check before launch. If any part is not functioning properly, the engines automatically shut off until trouble is cleared.

In this case, the firing box, located below the pad in the actuator pit, blew the explosive bolts in the holddown arms before the coded time of release. Probable cause was engine thrust—it set up a pad vibration that caused the firing box to prematurely release its stored charge. But with the "hold" and "kill" circuits still active (the umbilical cord was still attached) the engines shut off after the missile



. . . this firing box exploded holddown bolts



. . . these holddown arms ripped a skirt

lifted about 20 ft. The Titan settled back on the pad, crashed, and burned.
Solution: Condenser firing-box location was changed to make it less sensitive to engine vibration. Also, sequencer was patched so premature bolt removal would bypass the "kill" circuit and permit a premature liftoff.

Why this had not happened sooner is unknown, but one explanation is based on the first "B" missile's having an engine with slightly higher thrust value—possibly sufficient to cause the extra vibration. This is an example where the troublemaking equipment is not found on operational missiles—they do not use a "hold" and "kill" safety circuit.

MISSILE THAT KILLED ITSELF

Malfunction: First of the C series Martin Titan lifted off the pad on Dec 12, 1959 after a normal firing. Several seconds later the missile blew up without apparent cause. Initial observation indicated a possible random engine or structural failure. But high-speed motion pictures of the flight made observers suspect the destruct package.

Cause: On the day after these movies were viewed, a search in the wreckage uncovered the destruct package—and its closed relays proved the assumption correct.

Also, analysis of telemetered data showed initial acceleration and vibration during liftoff was higher than with other Titans. This investigation pointed to an overly sensitive relay.
Solution: But Martin took no chances that it was only an overly sensitive relay. The destruct package was redesigned with a double relay system on different axes. Now, a simultaneous vibration in two directions is needed before the destruct can fire without cause. Also, the relay was moved to a less critical vibration area—from engine compartment to an upper compartment. Again, operational missiles do not have destruct packs, so a similar failure could not occur.

THE TORN SKIRT

Malfunction: A Convair Atlas missile in a normal test firing tore the skirt that surrounds the rocket engine on the holddown arm.
Cause: Missile is held down by two arms under 2600-psi hydraulic pressure. These arms pin into a free-floating bearing in the missile body, with struts to a pad on missile side. When arms are vented, struts force pins to retract and arms to lift away. Uneven pressure caused one arm to drag and rip the missile skirt.
Solution: Venting on arms was changed so arm drag was eliminated; and changes in the holddown mechanism were made later. Operational missiles now merely sit on the "A" frame—no possibility of the arm catching the skirt.

THIS ONE POPPED

Malfunction: On Nov 12, 1959, while Lox was being pumped into Martin missile B-9, atmospheric pressure collapsed the missile fuel tank. This occurred after a minor leak was discovered during fueling, and after the tank had been emptied and the leak repaired.
Cause: Lox is pumped at low temperature; moving from the storage tank, it first cools the line before beginning to flow as a liquid. When

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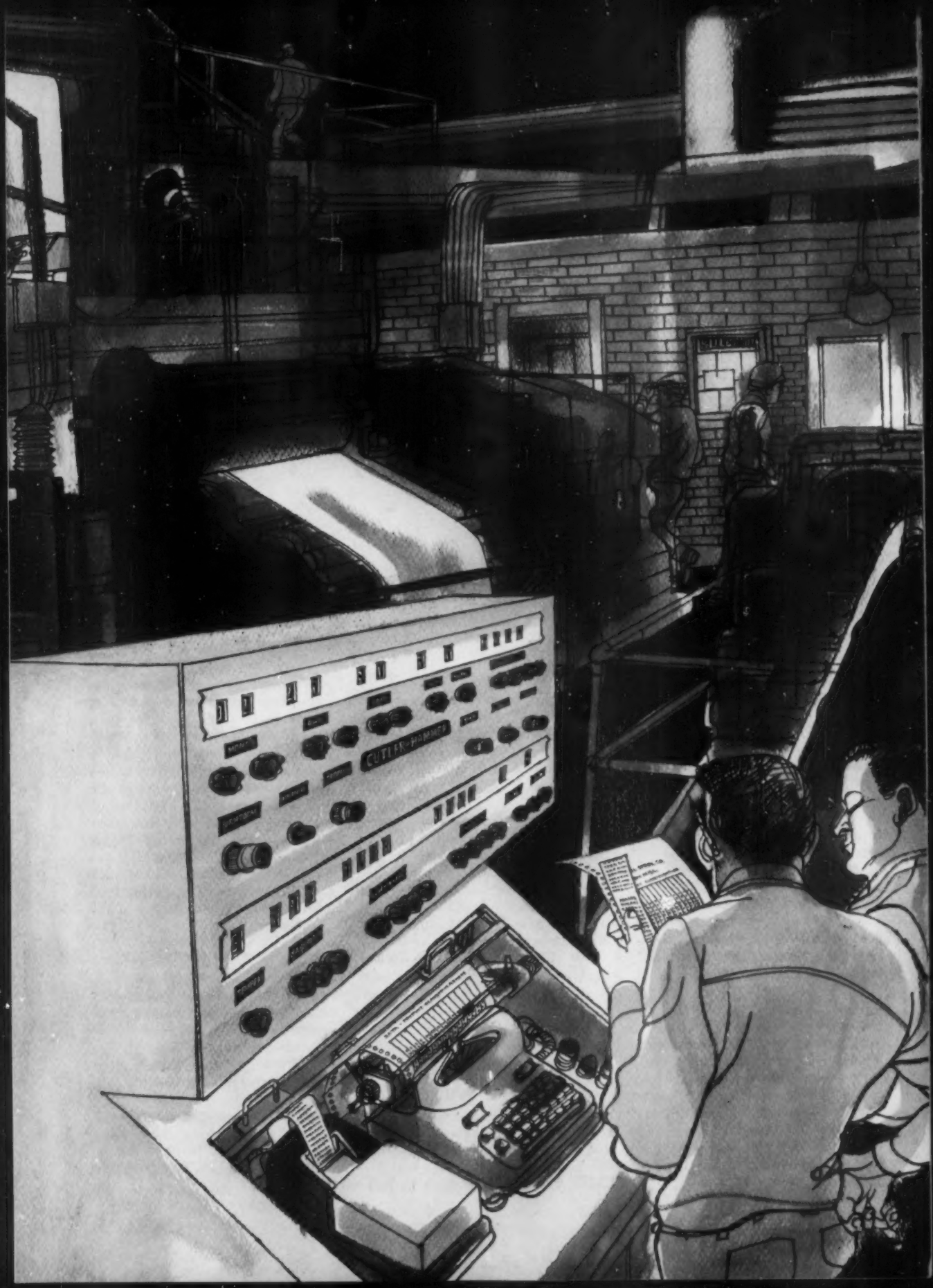

New machine with a memory licks a quality problem 3 miles long!

ANOTHER NEW IDEA FROM CUTLER-HAMMER

When manufacturers started ordering up to 16,000 ft. of tinplate in one coil instead of sheets, it created a serious problem.

You can control sheet quality by running each one through sensing stations and separating them by predetermined standards. But how do you check and control quality in over three miles of tinplate that's all rolled up?

For an answer, a leading tinplate producer came to Cutler-Hammer. Working with him, Cutler-Hammer engineers devised a simple, yet ingenious solution. They developed a new type of computer that hooks onto the same sensing stations used for individual sheets.

As miles of tinplate whiz by these sensing stations *before* it's coiled, this computer remembers every defect. Then, it automatically records every defect's type and location on a tape. After checking the tape, exact quality is known. Production controls can be adjusted quickly to compensate for any deviations from standards.

What's your problem?

Cutler-Hammer is on the move. It's brimming with new products—a limit switch, for instance, that's twice as dependable as the ones you now use. It has the ideas and the engineering talent for designing systems that automatically handle everything from blast furnace charging to quality control. And the addition of Airborne Instruments Laboratory's microwave and electronic experience gives Cutler-Hammer unmatched capability in all fields of industrial automation.

The new trademark you see above symbolizes the vitality, the capacity for ideas and practical assistance you can expect from the *new* Cutler-Hammer. Phone your nearest Cutler-Hammer office to put it to work for you.

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continued from page 17

the leak was discovered, the Lox was backed to the first shut-off position in the line. Although fixing the leak took only 30 minutes, this was enough for the missile tank to warm up. When pumping was restarted, cooling of the line did not occur—the line was already cold from holding Lox—so cold liquid Lox entered the warm tank, causing a sudden temperature and pressure drop. Result: an implosion.
Solution: All future fuelings call for slow chilling of the tank, with the vent line closed. Closing this line permits an internal pressure build-up —about 18 psi—which is similar to prestressing; and, of course, chilling lessens the chance for sudden temperature drops in the tank.

This was the first experience anywhere with this type of failure. After simulating the malfunction to be sure of the cause and solution, information was disseminated to all missile builders. Lox fueling procedures were checked and modified to include implosion information. However, a recent malfunction while fueling an operational missile at Vandenberg had all the characteristics of an implosion; officially, there is no verification.

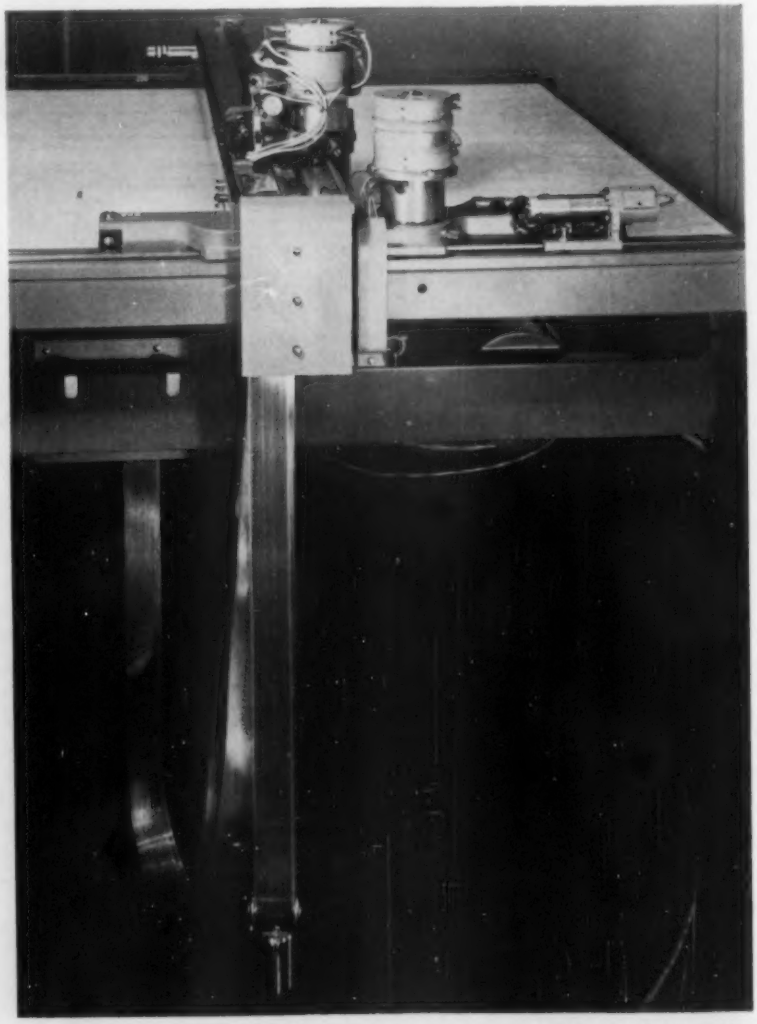
ENGINE THAT BURNED ITSELF

Malfunction: Early Atlas missiles were running into a series of mysterious failures—engines would cut out after successful launches but before the computed burning period.
Cause: Stumped by this, Convair went to the Arnold Engineering Development Center's wind tunnels to help solve the mystery. Surveys were made of various factors that might affect the engine burning rate. It turned out that the turbine exhaust was being directed straight back and the long steel skirts of these engines caused a partial vacuum. This tended to suck back the gases and burn the ignition harness.
Solution: Turbines are now vented to the sides; the skirts are now of fiberglass (a weightsaver) and have been cut back—the vacuum trouble is gone. For added safety a heat shield was added to protect the harness from extreme temperature.

TROUBLE UP FRONT

Malfunction: Nosecone recovery after successful firing was showing a bad batting average even though radar spotted and followed the flight. Twice this happened although reentry packages were equipped with parachutes to slow their descent near the water, flotation balloons to keep them afloat, signalling radios to bring in the searchers, and dye markers for spotting.
Cause: Again, Arnold Engineering Development Center helped solve the mystery. Surveys were made of the turbulence in the wake of the falling cone. Cameras shot thousands of frames in wind tunnel tests. And the unexpected answer was that the parachutes were at fault: they were not opening.
Solution: Air turbulence behind the falling nosecone was impeding the opening of the chutes. Arnold Engineers simply suggested longer shroud cords for the chutes. The chute could now open in the relatively calm air beyond the turbulence area. And, in subsequent flights, the score on nosecone retrievals went up. —**R E Abbott**

Automated Plotter Reads Tape or Cards



A two-year research and development program by Aero Service and the Franklin Institute, both of Philadelphia, has led to a fully automated coordinatograph that accepts tape or card input to plot grid systems or coordinate positions with an accuracy of 0.0015 in. Unit's maximum operating speed is 3 ips; slowest speed, 0.003 ips. Shown are recorder heads which have a resolution of 0.001 in., and Mylar ribbon tape which powers all electrical elements of the plotter. Used for precision layout of templets and charts, the unit sells for $34,750.

Advanced Controls Shown to Machine-tool Builders

PITTSBURGH — The innovations described and shown at the 24th Annual Machine Tool Electrification Forum here ranged from complete systems down to individual components. And the large number of engineers present came away with ideas of what to expect in machine controls during the coming year. Some of them felt that Westinghouse Electric Corp, sponsor of the forum, was also hinting at what might be found on machines at this coming September's National Machine Tool Builders Show in Chicago.

Product highlights of the two-day meeting were:

• PRODAC—a Westinghouse control that uses a rotating pulse generator for each moving machine element. The pulses are counted by transistorized modules mounted in a console. As shown on a new Gisholt Machine Co digital turret lathe, there is no fixed zero or reference point—zero is set by pushing a button when the machine has been set at its zero position. The control then keeps track of all further changes. One disadvantage: loss of power causes loss of zero setting, and the part being machined must be re-zeroed. Input is 1-in.-wide 8-channel punched tape. Servomotors are Trinistor-controlled, and accuracy is reported at plus or minus 0.0005 in.

• Electrical power meter, developed by Westinghouse for Blanchard Machine Co surface grinder, which directly measures current times phase angle. Advantage cited is lower cost compared to ordinary wattmeter, yet power meter gives a linear response compared with nonlinear response of simple ammeter. Meter responds to iron, friction, and windage losses, unless suppressed. Magnetizing current, displaced 90° from voltage, has no effect on the meter according to Westinghouse engineers.

• Nonadjustable multipole electromechanical relay, to be available soon, uses philosophy that it is better to have reliability than adjustability, even though complete replacement of a faulty relay is necessary. Relay is claimed to be smaller, lower cost, and is said to be good for 20 million operations. ■

Deciding Winners in PRODUCT ENGINEERING's Design Contest

Standing in judgment, here's the 6-man panel at work in the elimination stage of our first annual Awards for Achievement in Product Development. From 96 entries, 11 winners were chosen. The products that won will be on display next week in PRODUCT ENGINEERING'S booth at the 1960 Design Engineering Show & Conference, the Coliseum, New York City; and our next week's issue will carry the full story. The judges, left to right: Arthur M. Perrin, president, National Conveyors Co Inc; Renato Contini, senior research scientist, College of Engrg, New York Univ; George Habach, vice-president, administration, Worthington Corp; Milton Immerman, Walter Dorwin Teague Assoc; John H Robinson Jr, manager, advance engineering, General Electric Co; Robert Redman, professor of industrial design, University of Bridgeport.

Metal-powder Groups Merge as Industry Grows

CHICAGO—The three-year-old split in the powder metallurgy field was healed by a merger agreement between the older Metal Powder Industries Federation and the Powder Metallurgy Parts Manufacturers Association at the Federation's 16th annual meeting here.

The division was among contract manufacturers of metal-powder parts. Some of the largest resisted efforts to bring them into the Federation and formed their own organization in 1957.

Unification means that, for the first time, the American powder metallurgy industry has a single voice speaking for virtually all significant sections of the field—including powder producers, parts manufacturers, and equipment and materials suppliers. In the setup the parts manufacturers remain the "Powder Metallurgy Parts Manufacturers Association," but it is now a unit of the parent Metal Powder Industries Federation. Headquarters is to remain at 60 E 42 St, NYC, and Kempton H Roll, the Federation's executive secretary, will continue in this capacity in the new merged organization.

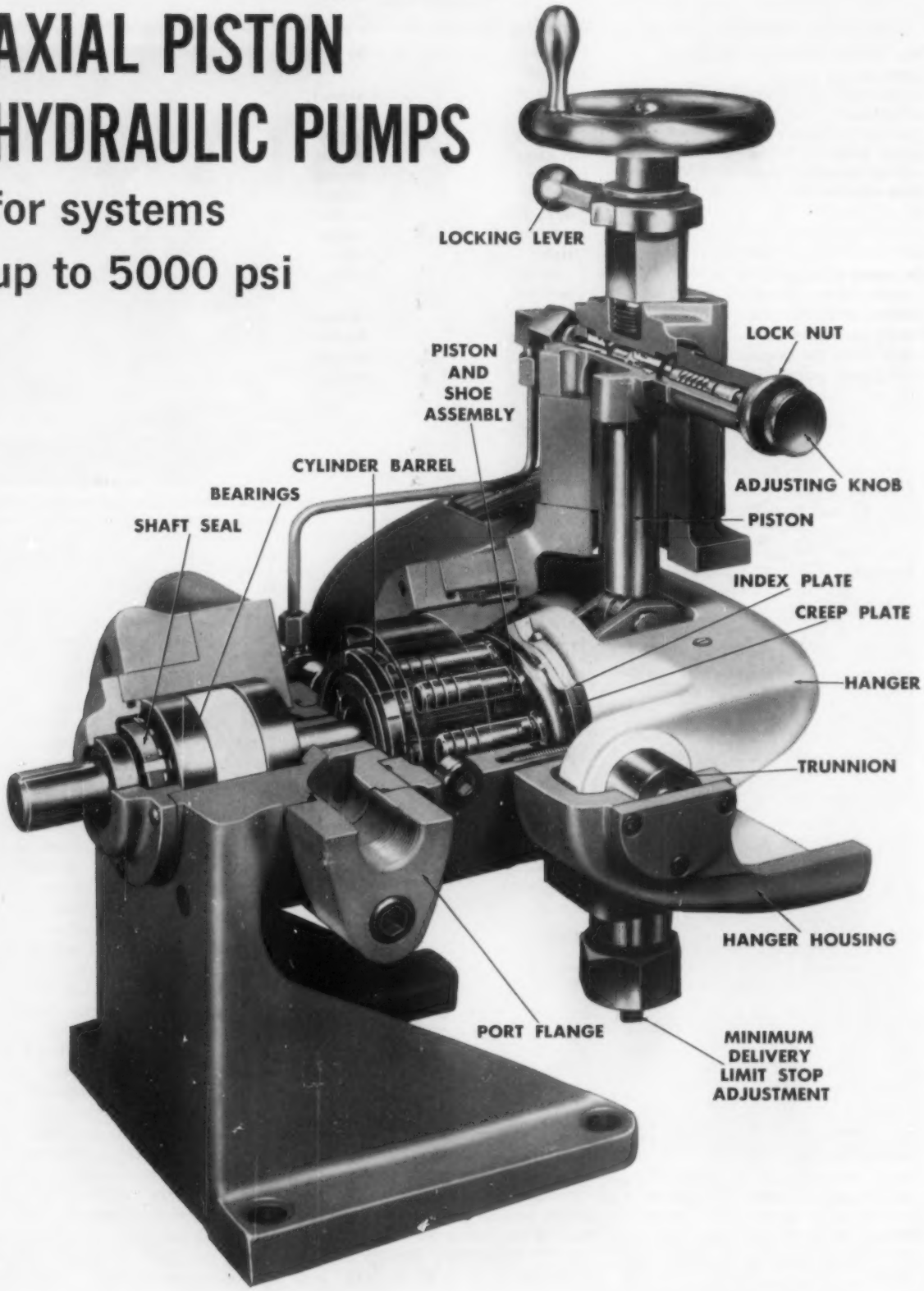
Giving his own report on the status of the industry, Rolls indicated that production and consumption of iron powder, bellwether of the field as a whole, is continuing to rise. Total 1959 figure was 35,000 tons. For the first time, more than half of the iron powder consumed went into the manufacture of structural or mechanical parts (other major uses are electronic and magnetic applications, cutting and scarfing, welding electrodes, friction materials). This growth trend is characterized by the design of an increasing variety of parts, particularly larger and heavier ones.

Roll predicted the next major gains in the application of metal powders for structural and mechanical components would be in the field of stainless materials where, he reported, technical complications have now been overcome, and both production and consumption are growing. —Jack Kolb

Design of variable volume

AXIAL PISTON HYDRAULIC PUMPS

for systems up to 5000 psi



By: Ellis H. Born

Director of Sales-Engineering
Denison Engineering Division
American Brake Shoe Co.
Columbus, Ohio

With today's ever-increasing requirements in the transmission of higher horsepower, the designer must look to hydraulic components that will give the greatest transmission efficiency with the lowest possible cost and the smallest possible package. With smaller, lighter, more powerful equipment—operating pressures of 2000, 3000 and 5000 psi are becoming commonplace. To meet the needs of higher pressures with a high degree of reliability, axial piston pumps and motors of proper design should be considered.

For 5000 psi requirements, the axial piston pump (illustrated) is a logical choice. It operates on the principle of a series of pistons in a common barrel that progressively draw oil into the barrel on the suction stroke and force oil from the barrel into the line on the discharge stroke.

With this simple axial piston design, direct and unrestricted flow into the pumping assembly is possible, eliminating the need for the large flow areas used and the moving seals which, in turn, eliminates maintenance. Direct flow path further insures good suction characteristics —a highly desirable operating advantage for obtaining efficient hydraulic performance.

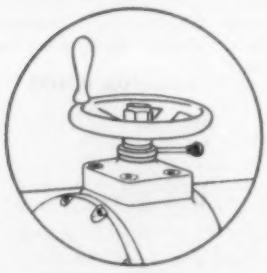
The port plate of the Denison pump is designed as an axial hydrostatic bearing which balances out the thrust of the cylinder barrel, leaving only sufficient force to create a positive seal contact between the cylinder port plate and the cylinder barrel. Because of reduced thrust, wear on mating surfaces is decreased and pump life is greatly extended at all pressures up to 5000 psi.

Where variable volume is required, it is logically desirable (for efficiency, simplicity and low maintenance) to eliminate the need for varying the position or angle of the cylinder barrel to regulate volume. In the Denison axial piston pump, output is simply regulated by varying cam plate angle. Zero to full flow or flow reversal is regulated by handwheel, hydraulic cylinder, stem, electric motor, compensator or electrohydraulically.

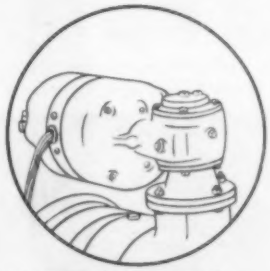
In the Denison design, the line of action of the combined radial load of all pistons is through the roller bearing supporting the cylinder barrel. The use of a large bearing provides non-deflecting support for these radial forces. As a result, unbalanced or twisting offset that would tend to unseat the cylinder barrel from the port plate is eliminated. A continuous, effective sealing action of the barrel against the port plate is maintained to promote high pumping efficiency.

Piston and shoe assembly design also reduces by one-half the number of ball and socket couplings found in other types of axial piston pump construction. The shoes hydraulically balance out all piston thrust, eliminating need for thrust bearings.

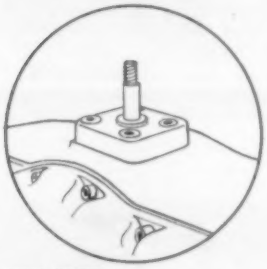
Data and specifications on 5000 psi pumps, motors and controls are available from your Denison representative—located in principal cities—to assist you in developing hydraulic systems for maximum efficiency and economy.



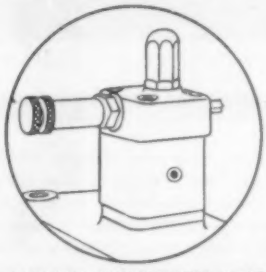
HANDWHEEL CONTROL
...with locking device for accurate manual pump volume regulation.



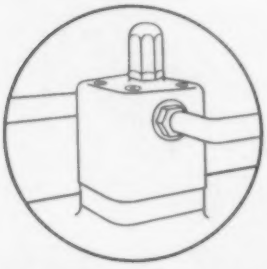
ELECTRIC MOTOR CONTROL
...adjusts pump volume to desired level. Integral brake in gear-head motor eliminates over-travel.



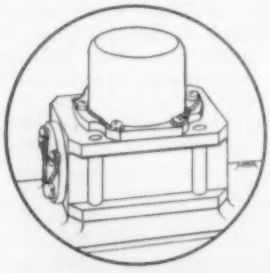
STEM CONTROL
...provides mechanical linkage to the driven equipment.



PRESSURE COMPENSATOR CONTROL
...affords automatic regulation of pump volume to meet preset pressure demands.



HYDRAULIC CYLINDER CONTROL
...similar to stem control, except volume is hydraulically regulated.



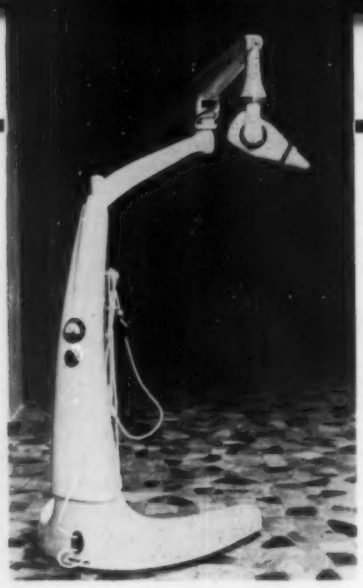
ELECTRO-HYDRAULIC CONTROL
...utilizes sensitive, system error-detecting unit which energizes hydraulic volume control piston.

NEW CATALOG FOR DESIGNERS AND ENGINEERS

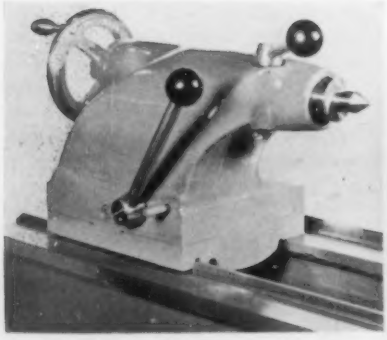
Write for your copy of Bulletin 220—"Hydraulic power to 5000 psi". Includes complete specifications, operating data and applications for Denison's full line of hydraulic pumps, motors and controls.

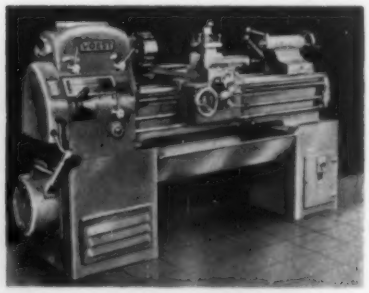
DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1194 Dublin Road • Columbus 16, Ohio

Recently designed electric locomotive, by Elin-Union AG, Vienna, contrasts sharply with baroque Austrian monastery of Melk.



Base of dental X-ray apparatus seems overly massive, for size and apparent weight of arms and head, but design is clean and borrows little from similar equipment in this field.





Except for the tailstock, far left, lathe made by Vereinigte Oesterreichische Eisen und Stahlwake AG, Linz, is relatively untouched by influences of modern machine design.

16 mm camera, right, looks as though it should blend firmly with hands, but judging by strap position, it might prove front-heavy in use. Made by Elektrizitaets and Metallwaren Industries, Vienna, camera is dated by chrome and crackle finish.

HUNGARY

■ Industrial design in Hungary developed simultaneously with industrialization of this country. The beginning was in 1954, when an Artistic Design Council and the Design Planning Institute were founded. These organizations were responsible, not only for developing designs for the home market, but also for coordinating sales-promotion and other programs aimed at increasing foreign sales.

Results were few during 1955, but the establishment of a faculty for industrial design at the Art Academy initiated a steady flow of designs. Young, newly graduated designers started becoming available to state enterprises each year. These designers already have an important voice in all stages of the development of new products. The first demands for the services of industrial designers came from the radio and motor-vehicle industries.

Hungarian industrial design, under the slogan "Only What Is Beautiful Can Be Good," has helped satisfy the requirements of technical progress. It has also helped to achieve product versatility, and economy of design and production.

Proof of this was provided at the Brussels Exposition of 1958, where Hungarian products were among those accorded recognition. Two of them—a grain processing machine and an air-cushion grinder—were awarded the Grand Prix, and like most of the others so honored, they, too, were the result of coordinating the work of the engineer and the industrial designer. Such coordination is already influencing Hungarian industry as well as consumers. This is because the demand for goods that not only have functional merits but also are esthetically satisfying is steadily increasing. ■

A prize-winning design of 1959, this single-phase electricity meter was designed by Dezsoe Bozzay.

AUSTRIA

■ If modern concepts of product development and marketing are ever to come to Austria, an attitude must first be overcome. This is the Austrian people's apparent inability to part with their possessions even after they become obviously outdated, less functional—and even unused. Spearheading the attempts to do this—for industry as well as the consumer—is Prof Karl Schwanzer. Together with a small group of like-minded industrialists, architects and artists, Dr Schwanzer in 1958 formed the "Oesterreichische Institut fuer Formgebung" in Vienna. The institute is jointly subsidized by the Austrian government and industry and maintains a list of designers—very limited and mostly architects by training—which it makes available to enterprises desiring such service. The institute encourages designers to freelance for various firms so that wider experience and versatility can be developed.

One of the first things that the designers, educators and others associated with the institute did was to review Austria's more recent economic development. Some natural obstacles to an earlier start for industrial design were revealed. World War II isolated the country from much world progress. The damages of the war were largely overcome in the "sellers' market" of the 1945-to-1953 reconstruction period. The following turn to the "buyer's market" in the stabilization and expansion period coincides with the beginning of an interest in industrial design. Like that of most Europeans, the Austrian mentality forbids design for any kind of artificial obsolescence, but a new, more modern attitude toward design has developed during the past five years—spurred by imports, rather than domestic work.

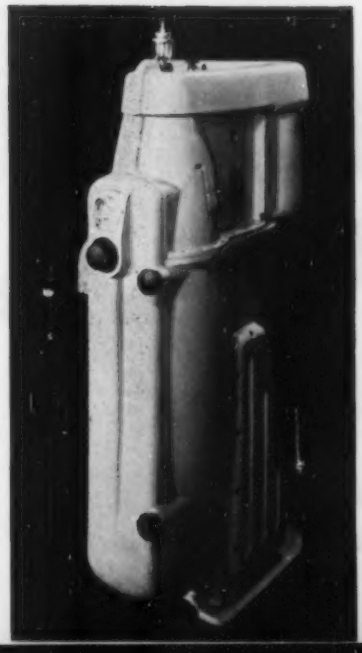
Austria's largely crafts-shop type of production (as opposed to large-scale industries) produces small quantities of a given product, owing to the small (population: 6.7 million) domestic market. Exports cannot compete in quantity—and craftsmanship alone cannot sell products abroad to any great extent. Modern design is seldom part of the planning of these products.

Much older than Austrian industrial design is the "Kunstgewerbe," an occupation not easily described because of its versatility and complexity. Essentially, it is a craft that serves to originate mostly small, artistically-shaped decorative goods which, later, are produced in small number. Major emphasis is on esthetic appearance rather than function. The Austrian character—lots of imagination, a certain desire for comfort, and a pronounced artistic "feel" refined by centuries of cultural activity and exchange—is clearly seen in this craft activity.

While "Kunstgewerbe" continues to deal mainly with decorative goods, industrial design has begun to reach far across the field of durable consumer goods and has even begun shaping industrial products such as machinery, instruments and the like.

Today, customs duties are still too high for most Austrians to import a Swedish chair, a French desk, Italian shoes or pullovers, but the regional economic groups developing throughout Europe will gradually open the borders, creating a threat to local manufacturers if their designs are not up to modern standards.

"The customer's taste is not as bad as some manufacturers say," according to Frau Dr. Charlotte Blauensteiner, secretary of the Vienna institute. "This is evident from the demand—despite customs duties—for chairs, desks and shoes. Austrian manufacturers will be increasingly forced to apply good design to their products, or else they must face—and probably lose to—foreign competition."■



Centrifuge designed by Emil Gozzay and Jozsef Daniel also won a prize last year. An earlier model, had many more grooves, ridges and dirt-catching corners. Those that remain, apparently for decoration, tend to detract from machine's sculptural simplicity.

Theodolite's compactness avoids fussy look of many instruments of this type and probably adds to ruggedness and all-weather usefulness.

Lathe tailstock and bed are suitably complemented by lines of base. Selections of settings is likely to prove difficult because of inadequate readability. Lower controls can be accidentally bumped out of adjustment—especially when that built-in footrest is in use.

EVEN ON THIS EXTRA-TOUGH JOB...

N-A-XTRA

HIGH-STRENGTH STEEL TRIPLES TRUCK LIFE!

Hour after hour, around the clock, the Edward C. Levy Slag Company, Detroit, keeps forty 45-ton trucks working under severe conditions. Nearly 30 tons of hot slag are loaded, lifted and dumped on every trip. Each time, the truck body must stand the sudden shock of drop loading, the stress of lifting that load and the grinding abrasive action as it empties.

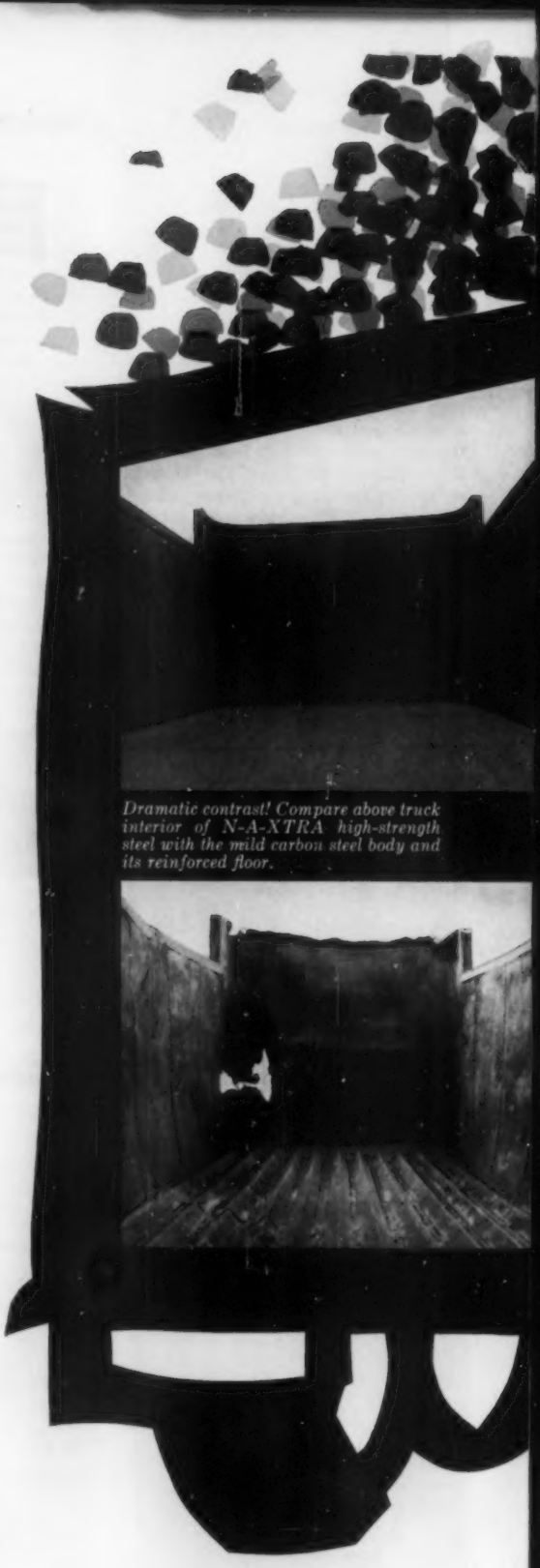
How long can a truck body take such a beating?

Until the company (which designs its own trucks) discovered N-A-XTRA high-strength steel, they used ordinary carbon steel, good for about 18 months' service. Though the truck bodies were as strong as they could be and still carry an adequate payload, maintenance was almost continuous—with breaks, dents, dings and sags occurring almost from the start.

Then they fabricated eight bodies out of N-A-XTRA, which has a minimum yield strength nearly three times greater than mild carbon steel. These trucks carry the same payload and after 18 months' service still look almost new. Owners estimate a life of five years, more than triple the others—with far less maintenance. The extra strength of N-A-XTRA also permits a strong floor that needs no expensive reinforcement to support the load against hydraulic lift action.

Eventually, all forty Edward C. Levy trucks will be made of N-A-XTRA high-strength steel. In fact, all patches and section replacements are now made with N-A-XTRA.

Tons of hot, abrasive slag may not be your problem—but the same steel that mastered these conditions is the one to remember when only the strongest steels will do. Rugged conditions, heavy loads and weight-saving construction are challenges that N-A-XTRA is designed to meet and beat. With excellent weldability, formability and toughness, these quenched and tempered N-A-XTRA steels are available in four levels of minimum yield strength, from 80,000 to 110,000 psi. They can also be supplied to higher levels of mechanical properties.



Dramatic contrast! Compare above truck interior of N-A-XTRA high-strength steel with the mild carbon steel body and its reinforced floor.

N-A-XTRA

A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

These two trucks have done the same tough work for 18 months. The only difference is that the one above is made of N-A-XTRA.

DESIGN NOTE:

Panels and floors for these trucks, designed by Edward C. Levy Slag Co., were fabricated of N-A-XTRA 100 (100,000 PSI minimum yield strength) from plates 3/16"-1/2" thick. Standard flame cutting procedures were used. Side frames were cold-formed of N-A-XTRA 100 from 3/16" plate, using both skip (6" weld, 6" skip) and continuous welds. Performance to date has been equal, indicating additional savings through skip welding.

For full technical information on N-A-XTRA high-strength steels, write Great Lakes Steel Corporation, Detroit 29, Michigan, Dept. C-9.

***Great Lakes Steel is a Division of* NATIONAL STEEL CORPORATION**

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Andy Anchor says:

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ANCHOR HOSE ASSEMBLIES with ANCHOR Pressed-On Couplings are available for high, medium and low pressure service with maximum working pressures ranging from 12,500 PSI for 3/16" I.D. 6 Ply Super Spiral Hose to 100 PSI for 2" I.D. Spiral Wire Suction Hose.

ANCHOR REUSABLE COUPLINGS — Regular or Clamp Type, are available for emergency repair and year-to-year superior performance for high, medium and low pressure service ranging from 5000 PSI for 1/4" I.D. 2-Wire Braid Hose to 100 PSI for 2" I.D. Spiral Wire Suction Hose.

ANCHOR 4-BOLT SPLIT-FLANGE "O" RING HEAD COUPLINGS are available in a wide range of sizes for high, medium and lower pressure applications.

ANCHOR ADAPTER UNIONS, PIPE FITTINGS, SAE BOSS TYPE FITTINGS A complete line of Pipe and Tube Fittings, Adapter Unions and SAE Boss Type Fittings are offered in a variety of styles and sizes to satisfy the requirements of any installation.

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28 CIRCLE 28 ON READER SERVICE CARD

READER TO EDITOR

Surveyors, Wear Your Rubbers

To the Editor:

My usual pleased reading of your magazine was somewhat disrupted this morning as I went through your item "Bring in the Astronomers" (Apr 18, p 3). The problem of running the NW boundary of the state of Delaware was a bit more complicated than you have put it. The line between Delaware and Pennsylvania is based on a circle of 12 miles radius, laid off from the courthouse in Newcastle as a center. If the surveyor followed this strictly, he would have landed in the water (Atlantic Ocean and Chesapeake Bay).

Mason and Dixon had the pleasant task of locating a line 10 miles south of the southern boundary of Philadelphia, which was then also undefined. This sets the boundary of Pennsylvania and Maryland (about 39°30′ N). I believe the result of all this map scratching was to leave a square foot or two outside of all three states and hence not taxed. I hope this bit of history has not disrupted your pleasant morning as it is really a little thing in comparison with the many other valuable items you present.

—Charles E Balleisen
Dallas, Tex

Name Dropper

To the Editor:

We have read with interest the story on the Research Triangle Park of North Carolina which appeared on p 15 of your Mar 21 issue. However, you mentioned in the sixth paragraph that the first industrial lab to locate in the park is a "Celanese Corporation installation." We wonder if you didn't mean the Chemstrand Corporation.

—Kenneth C Beene
Chemstrand Corp
Decatur, Ala

• Yes, we did mean Chemstrand Corp. —Ed.

Developments in Steam-treated Tools

To the Editor:

We noted with interest your report on p 8 of the Mar 21st issue regarding steam-treating of tools in the Soviet Union. We were particularly interested in the implication that this is a new development of Soviet technology. As long ago as 1938, Perfect Circle of Indiana was experimenting with the idea of heat-treating cast iron piston rings in a steam atmosphere to coat them with a thin oxide film (Fe_3O_4) that retained lubricant and also had corrosion-resistant properties. They were successful enough to obtain patents in 1941.

The Buick Motor Co, hearing of the work, became interested in steam-treating valve tappets and both Perfect Circle and Buick approached us to build a suitable furnace. From these requests grew the widely used Steam Homo line of furnaces. By 1942, work done by National Twist Drill in steam-treating high-speed

steel proved so successful in lengthening the life of drills, reamers, etc., that steam-treating soon became standard practice for manufacturers of high-speed tools in this country.

Today use of the Steam Homo method has proved beneficial to a wide variety of both ferrous and nonferrous products, such as powdered-metal compacts, molded rubber parts, beryllium-copper, brass and bronze parts.

—H F Coyle, *head*
Furnace Section
Market Development Div
Leeds & Northrup Co

COMING EVENTS

MAY

9-13 . . . Society of Photographic Scientists and Engineers, 1960 Annual Conference, Miramar Hotel, Los Angeles

9-13 . . . American Society for Metals, Southwestern Metal Show, State Fair Park, Dallas

10-12 . . . American Institute of Electrical Engineers, Institute of Radio Engineers, Electronic Industries Assn, Western Electronic Manufacturers Assn–Electronic Components Conference, Washington, DC

18-20 . . . Society for Experimental Stress Analysis, Stress Analysis in Propulsion Systems, Indianapolis

23-26 . . . American Society of Mechanical Engineers, Design Engineering Conference, New York Coliseum, NYC

23-26 . . . Clapp & Poliak, Design Engineering Show, New York Coliseum, NYC

23-26 . . . American Institute of Electrical Engineers, Instrument Society of America, American Rocket Society, Institute of Aeronautical Sciences–National Telemetering Conference, Marimar Hotel, Santa Monica, Calif

JUNE

10-26 . . . British Exhibition, New York Coliseum, NYC

13-15 . . . Metal Powder Industries Federation and American Institute of Mining, Metallurgical & Petroleum Engineers, jointly sponsoring International Powder Metallurgy Conference, Hotel Biltmore, NYC

19-21 . . . Alloy Casting Institute, Annual Meeting, The Homestead, Hot Sprngs, Va

20-24 . . . American Society for Engineering Education, Annual Convention, Purdue Univ, Lafayette, Ind

26-July 1 . . . . American Society for Testing Materials, Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, NJ

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Money saving ideas and design suggestions on Fabricated Wire Cloth Parts. Strainers, filters, inserts... in any metal, all meshes, to your specifications. Large or small runs. Simple or complex parts. Special metals such as "Inconel", "Monel", "Nichrome" and stainless steel.

Our engineering service includes not only a thorough analysis of your parts, but also a careful study as to the type of cloth best suited to your needs.

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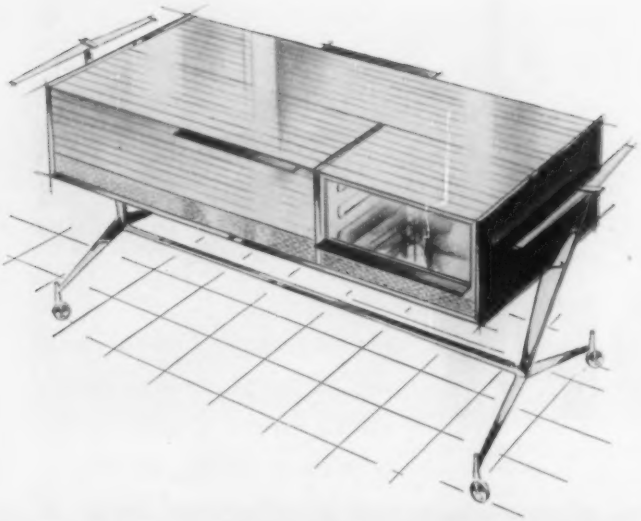
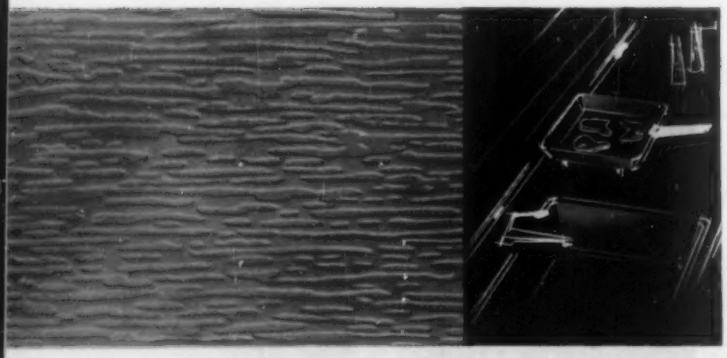
Carl Sundberg and Montgomery Ferar joined fortunes in 1934 and since have had a great influence on improving the design of mass-produced consumer and industrial products.

One of the largest of the nation's recognized design firms, they have put their talents to work on hundreds of nationally known products ranging from pencil clips to heavy-duty motor trucks and electronic computers. Recognized leaders in the design of electrical appliances, they are permanently retained by many of America's best known appliance manufacturers.

Sundberg-Ferar designs a unique, portable kitchen caddy with wonderful....





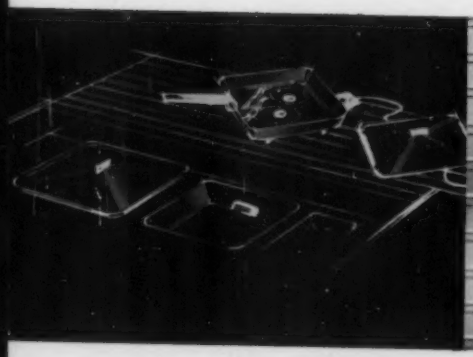
• Sharonart® is truly the designer's metal. Evidence of this fact is this modern kitchen caddy designed in Sharonart® by Sundberg-Ferar, one of the oldest, largest and most successful industrial design firms in the United States.

The portable caddy permits complete cooking facilities anywhere inside or outside of the home. To make sure it would be able to absorb the punishment of daily use, yet stay bright and clean, Sundberg-Ferar designed the cabinet and working areas in patterns of Sharonart® Stainless. Wood grain Sharonart® steel panels at each end give the furniture-look that blends with other home furnishings.

The textured beauty of Sharonart® can be produced in an almost limitless number of patterns. This permits easy model changing. It's easy to clean and will not show wear. It can be painted, plated, or vinyl coated with beautiful results. Is it any wonder that more and more of the leading designers are turning to modern Sharonart® for modern product design? *Sharon Steel Corporation, Sharon, Pa.*

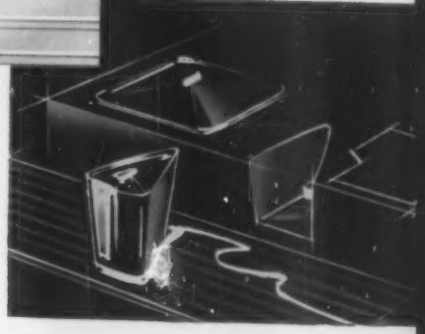
About the portable kitchen caddy: This is a design only, produced to show the tremendous utility of Sharonart®. All the seemingly built-in utensils are self-energized, and can be plugged into any electrical outlet as well as being used with the caddy itself. The rotisserie has vertical elements that can be moved closer together for the smokeless vertical broiling of steaks. All utensils are removable and can be used at the dinner table for gourmet cooking. Plenty of workspace is provided for complete meal preparation right at the caddy.

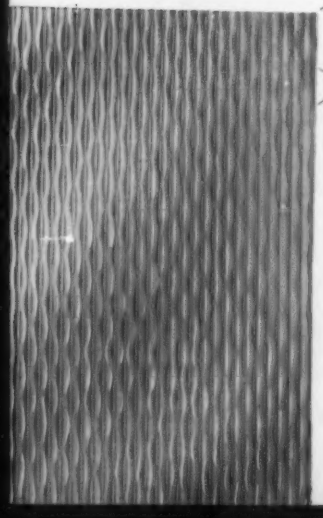
CIRCLE 30 ON READER SERVICE CARD



Steel

SHARONART®





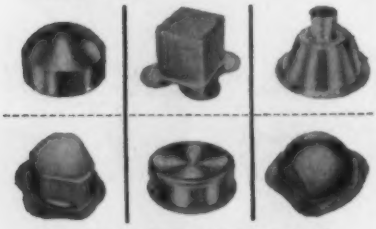
SHARON *Quality* STEEL

SHARONSTEEL

KAUPP
PRECISION-FORMED
METAL
COMPONENTS

Hydroforming, Deep Drawing and Spinning

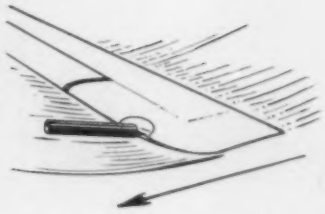
You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

C. B. KAUPP & SONS
Metal Craftsmen since 1924
NEWARK WAY, MAPLEWOOD, N. J.
Telephone: SOuth Orange 3-2490

WHY DON'T THEY R&D..?



. . . an accurate method of measuring airspeed of helicopters in the range between hover and 40 mph. A device developed by Cornell Aeronautical Laboratories Inc, and described in its newsletter, *Research Trends*, (Winter issue, 1960) seems to answer many of the problems; but some difficulties still remain.

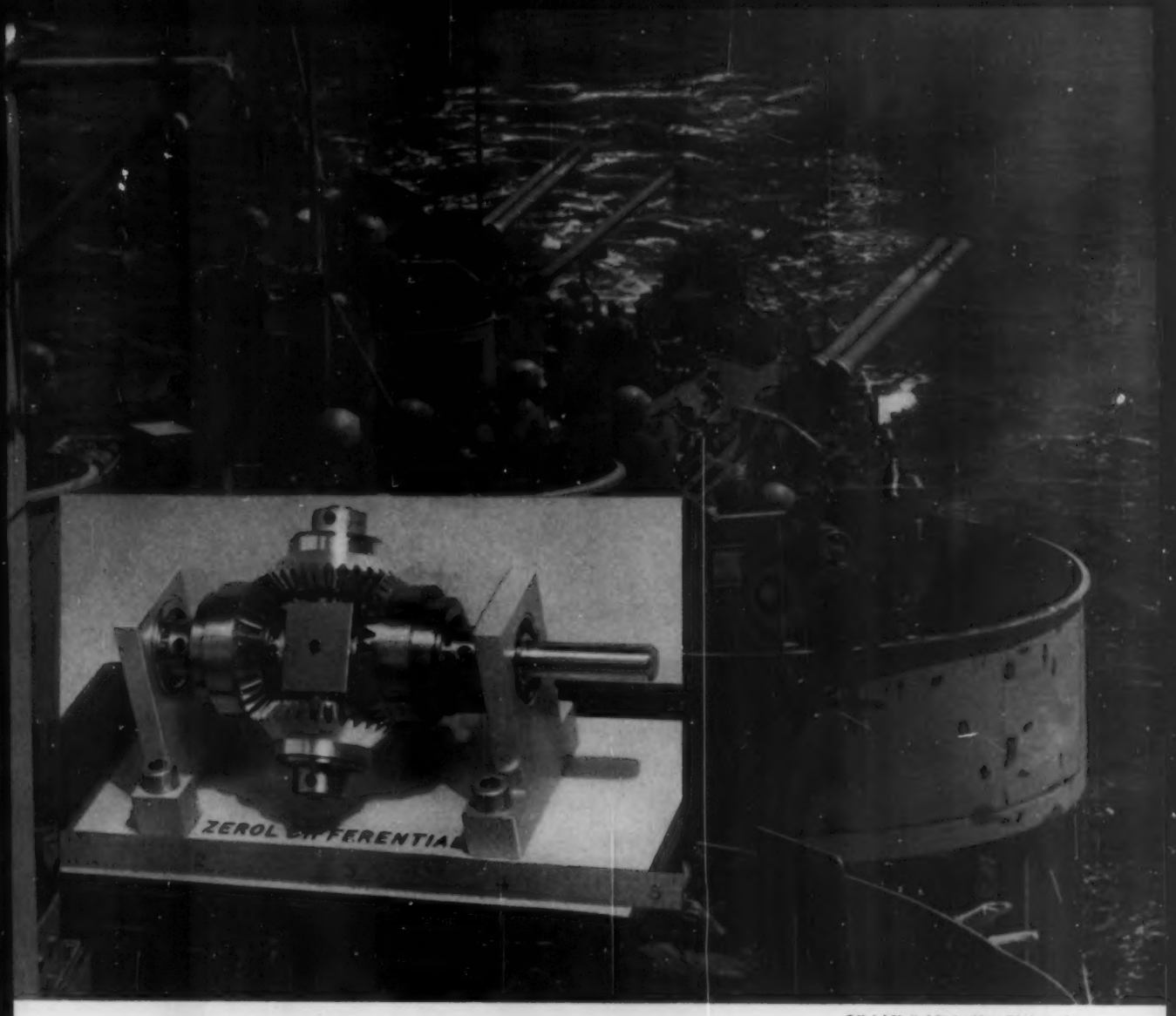
The Cornell instrument neatly skirts the usual problems in measuring low airspeeds of helicopters with conventional pitot tube and pressure-gage instrumentation: (1) it is difficult to make a gage sensitive to very small pressure differentials and still have it useful in the 50-100 mph range; (2) downwash from helicopter blades blankets the pickup tube, causing currents that interfere with its readings. Hence conventional airspeed indicators are not much good below 40 mph. Cornell engineers have placed the pitot tube at the tip of the revolving blade. Dynamic head is sampled as the blade swings through the upstream (moving in the same direction as the aircraft) arc and this is compared with downstream pressure readings to give indicated airspeed. Left-right motion can be detected by taking pressure readings when blade is parallel to axis of aircraft. This system will sense airspeeds as low as 1 mph, as far as can be determined (surface wind and intermittent gusts make it difficult to calibrate the instrument against true airspeed at indicated speeds below 6-7 mph.)

But besides difficulties of calibrating the instrument, two effects still defy satisfactory explanation. The calibration curve of true airspeed vs indicated airspeed is nonlinear in the range between 0 to 25 mph. And during autorotation, indicated airspeed is consistently lower than readings taken when blade is under power. Accurate indication of airspeed is needed for testing hover and stability of helicopters—characteristics that are particularly sensitive to small changes in airspeed at low velocity. And all-weather flight capability and operation from aircraft carriers is also hampered by lack of an accurate low-velocity airspeed indicator.

. . . a surge-current limiter for household incandescent lamps. The most critical instant for a light bulb is the moment it is switched on—most bulbs burn out during this brief instant. A device that limited the damaging inrush of current, allowing it to build more slowly to peak value, would prolong light-bulb life many times. Thermisters do this job in some radio and TV sets, but are expensive. Ideally, the surge limiter should be a small wafer inserted in the socket before the lamp is screwed in. Or, if sufficiently reliable, it might be made in a form that could be built into the socket.

—T N Tyler

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.



Official United States Navy Photograph

When your fine pitch gears *must be accurate*

When you work with fine pitch gears like those in this naval fire control unit differential, tolerances are critical.

Tooth-to-tooth accuracy is extremely important to permit the guns to be sighted precisely on target.

So where accuracy is really critical in the gears you make, Gleason can help you three ways:

1. Machines that cut or grind any fine pitch gear

You can produce any fine pitch gear—spiral bevel, hypoid, Zerol®, or Coniflex®—exactly and economically with any of five Gleason machines.

Three automatic gear-cutting generators cover the entire field of cut fine pitch bevel gears up to 4½" diameter. Two automatic, wet-type grinders are available for this same range of work and produce the ultimate in accuracy. All five work to your most rigid specifications.

2. Machines that test gears thoroughly

The Gleason No. 104 Hypoid Tester, for example, checks running qualities, tooth spacing, and concentricity of gears. It records test results on paper so that you have a permanent record of the total tooth-to-tooth composite error.

3. Engineering services

Gleason engineers are ready at all times to help you with any phase of the design and manufacture of fine pitch gears.

Simply write or phone for prompt assistance on any of your fine pitch gear requirements.

Send for these bulletins:

No. 2A Straight Bevel Coniflex® Generator
No. 103 Straight Bevel Coniflex® Generator
No. 2 Hypoid Generator
No. 105 Straight Bevel Coniflex® Grinder
No. 7 Hypoid Grinder
No. 104 Hypoid Tester

GLEASON WORKS

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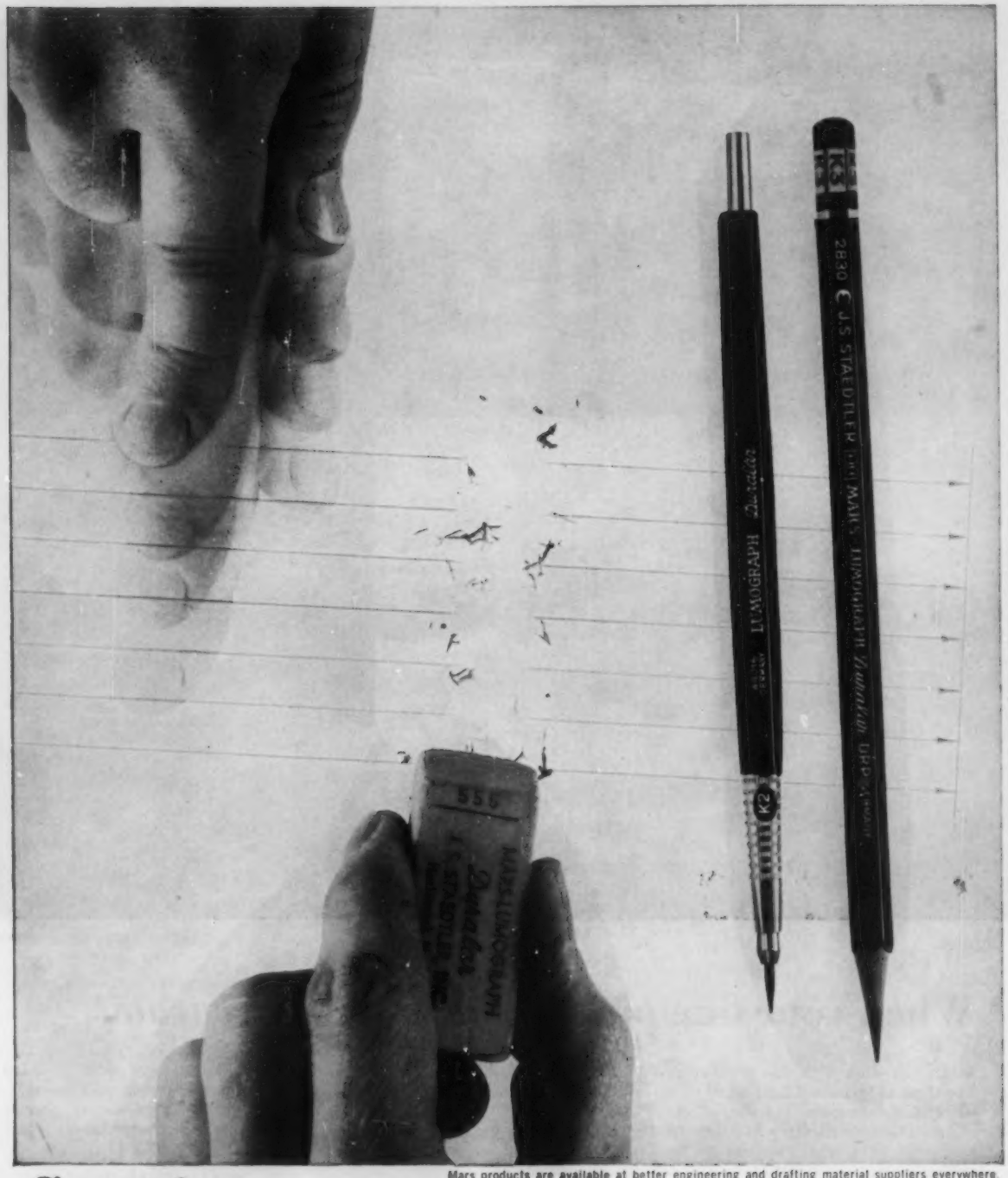
CIRCLE 33 ON READER SERVICE CARD



Mars products are available at better engineering and drafting material suppliers everywhere.

Duralar:

WON'T SMEAR ON MYLAR - ERASES ON MYLAR

Specifically designed to work perfectly on matte-surface drafting film of Mylar®, Duralar is the newest in the complete line of Mars fine drafting products. All are imported from West Germany and are made to meet the highest professional standards. Shown: Mars-Lumograph Duralar pencil and lead—available in five special degrees, K1 to K5; Mars-Duralar Technico with adjustable Duralar degree indicator; Duralar eraser.

®T.M. for duPONT's Polyester film.

the pencil that's as good as it looks **MARS**

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

This cylinder for a hydraulic press was cast and machined in a Blaw-Knox Steel Foundry. Weight—231,000 pounds.

Blaw-Knox Steel Foundries have machine capacity to handle the most unusual product requirements

Planing, turning, milling, or boring the most unusually dimensioned casting is no problem in a Blaw-Knox Steel Foundry. There you will find planers up to 15 feet × 15 feet × 36 feet, lathes with an 84 inch swing, and planer type milling machines up to 6 feet × 6 feet × 25 feet. In the same machine shops, you will find the smallest precision tool room equipment.

This huge line-up of tools is part of the basic equipment of each of the five Blaw-Knox Steel Foundries. Because Blaw-Knox is one of the world's leading builders of rolling mills and industrial machinery, its machine shops are equipped to handle all of the operations necessary to finish a steel casting for assembly into the complete unit or sub-assembly.

Machining to exact specifications with a wide variety of tools is another way Blaw-Knox Steel Casting Service adds value to your product. There is no need to ship the rough casting to another location for machining. You have the advantage of a single responsibility from patternmaking to shipping.

If you design or build a product using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Casting Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

BLAW-KNOX

Steel Castings

CIRCLE 35 ON READER SERVICE CARD

DOW

NEWS ABOUT PRODUCT DESIGN AND MATERIALS

The most important of the "new" products to hit the retailers' shelves these days are actually old products dressed up with the modern designs featuring the generous use of plastics. In fact, the importance of plastic's economy, versatility, and sales appeal has changed the study of plastics product design from "how to use" to "how much can be used." Here are some examples, old and new . . .

HOW MODERN PLASTICS HELP DESIGNERS MAKE FUN PAY OFF

Designers of products for today's $40 billion leisure market are turning more and more to materials offered by Dow's extensive line of thermoplastics. The reason: They get lightness, production economy, attractive finish, and chemical resistance —all in one material. And should they want to highlight one or more qualities above all others, they have several different formulations within each group. Take the application of Dow plastics for the "compleat angler" . . .

Good design from a sporting goods manufacturer's point of view usually means a finished product with a good balance of over-all qualities, and special emphasis on toughness. Designing this integrated spinning reel-handle combination, for example, required a material with extreme toughness to take the shocks and knocks in a fisherman's day.

Yet to streamline the time and expense of production, it had to have molding characteristics that would ensure a faithful reproduction of the fine details and close tolerances with a minimum of machining and finishing operations.

Tyril®, a Dow styrene-acrilonitrile copolymer answered both requirements for the design engineer, and it threw in an extra measure of resistance to heat, chemicals and cracking for the benefit of both manufacturer and fisherman.

In the fisherman's tackle box, another Dow plastic – Styron® – is making a name for itself as a material for molding colorful lures with long-lasting fish-appeal. Several different formulations are available, the right one depending on the individual requirements for each lure. Styron 683 is most economical and can be molded into a wide range

The strength, moldability, and sales appeal of this threesome—spinning reel of Tyril, lures of Styron, first-aid kit of polyethylene—demonstrate versatility of Dow thermoplastics.

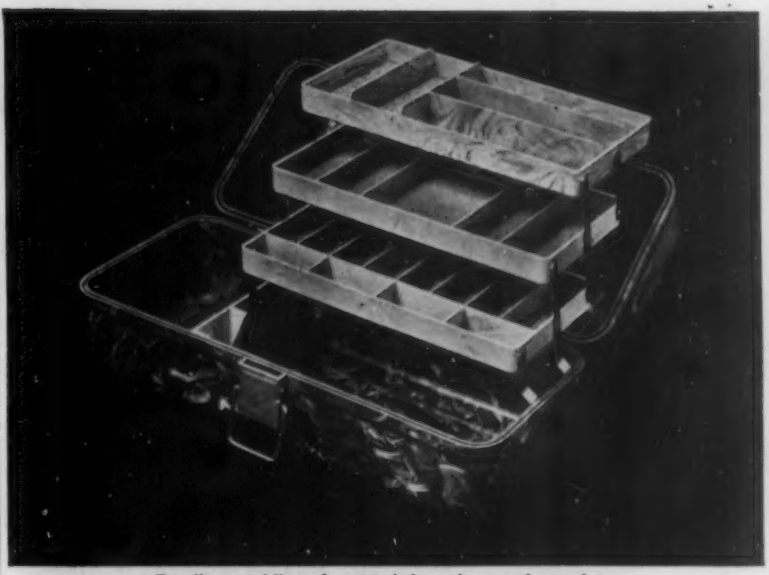
of tempting colors and shapes. Or a high-impact formulation, such as Styron 475, provides the strength and extra toughness to withstand even the most powerful striking jaws! Extra fabrication and finishing operations are unnecessary with Styron formulations. The surfaces are smooth and attractive when removed from the molds.

It floats! Polyethylene formulations present a variety of uses, tailor-made for the leisure market. Polyethylene 510, for instance, serves as a floating first-aid kit for boaters. This formulation gives the package toughness, chemical stability to withstand rust and mildew attacks, and most important, it guards its precious cargo of bandages, ointments and antiseptics against water damage.

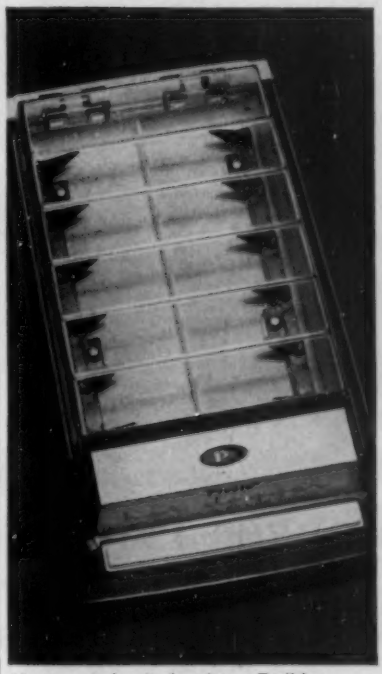
Here's a tackle box (right) to incite envy in any sportsman. It's built to take rough treatment, it's virtually rustproof, and it's good looking. The case is molded of Styron 480, a Dow super-high-impact plastic, with a green and white marbleized color effect. A unique tongue and groove design seals out water when the box is closed—even allows it to float! This feature was made possible by the excellent molding properties of Styron 480 . . . in this case its easy flow characteristics.

Any lunch time is transformed into a picnic when you serve hot dogs, cooked in a jiffy in this attractive Tyril hot dog cooker. The features of Tyril are right at home in this application. Its chemical resistance shrugs off food acid attacks . . . its heat-resistance and dimensional stability allow it to withstand cooking temperatures . . . and Tyril is virtually unbreakable.

A must for all sportsmen—campers, boaters, fishermen, picnickers – the flashlight is often the least considered, but most important equipment of all. Since dependability is its first requirement, one manufacturer molds the case of super-tough Ethocel®, the aristocrat of thermoplastics. The toughness of Ethocel (over a wide temperature range), its dimensional stability, and extreme shock resistance help this flashlight take all the punishment an active sportsman can devise, and still work when he needs it, and with its built-in air chamber, it floats!



Excellent molding characteristics, plus tough, outdoor performance recommend Styron for this tackle box.



Heat- and chemical-resistant Tyril becomes an attractive hot dog cooker.

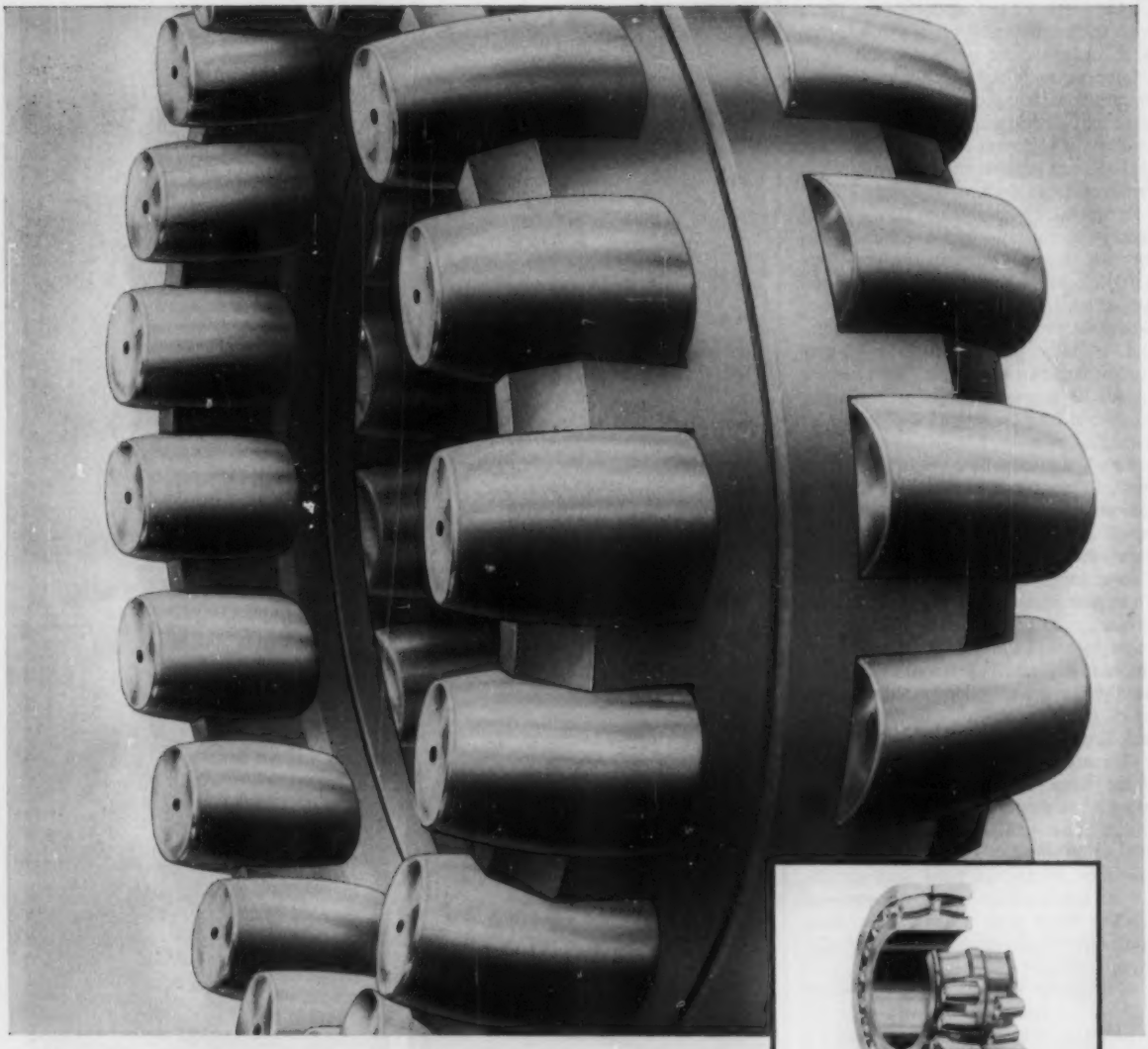
Super-strong Ethocel gives flashlight extra dependability, longer life.

WHAT'S ON YOUR BOARD? An idea for a new design . . . or a way to make an old product more attractive? Chances are modern Dow plastics can add to the physical properties and sales appeal of either. The Dow line of thermoplastics materials and formulations is the widest in the industry, and behind each formulation stands the specialized Dow technical service. May we serve you? Please write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Merchandising Department 1718DZ5-16.

THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

DOW

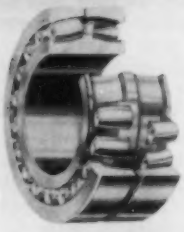
See "The Dow Hour of Great Mysteries" on NBC-TV



"Caged" for Longer Life!

The two land-riding cages in Torrington Spherical Roller Bearings assure proper roller spacing and guidance, even under rugged conditions of shock load and sustained high speeds. These fully machined cast bronze cages operate independently. Their design eliminates drag on rollers. These high-strength cages help bearings give longer life by providing low friction, smooth running and cool operation. Highly effective and generous lubrication of all contact surfaces is achieved with the open-end cage design.

The result: Torrington Spherical Roller Bearings are built to give extra years of unmatched service life in heavy-duty applications. Torrington's long experience in design, engineering and manufacture of every basic type of anti-friction bearing provides the finest spherical roller bearings available. You'll find it pays to standardize on Torrington.



Superior design features of TORRINGTON SPHERICAL ROLLER BEARINGS

- integral guide flange for roller stability
- asymmetrical rollers seek flange for positive guidance
- electronically matched rollers
- size-stabilized races
- fully machined land-riding bronze cages
- controlled internal clearances
- even load distribution
- inherent self-alignment
- long service life

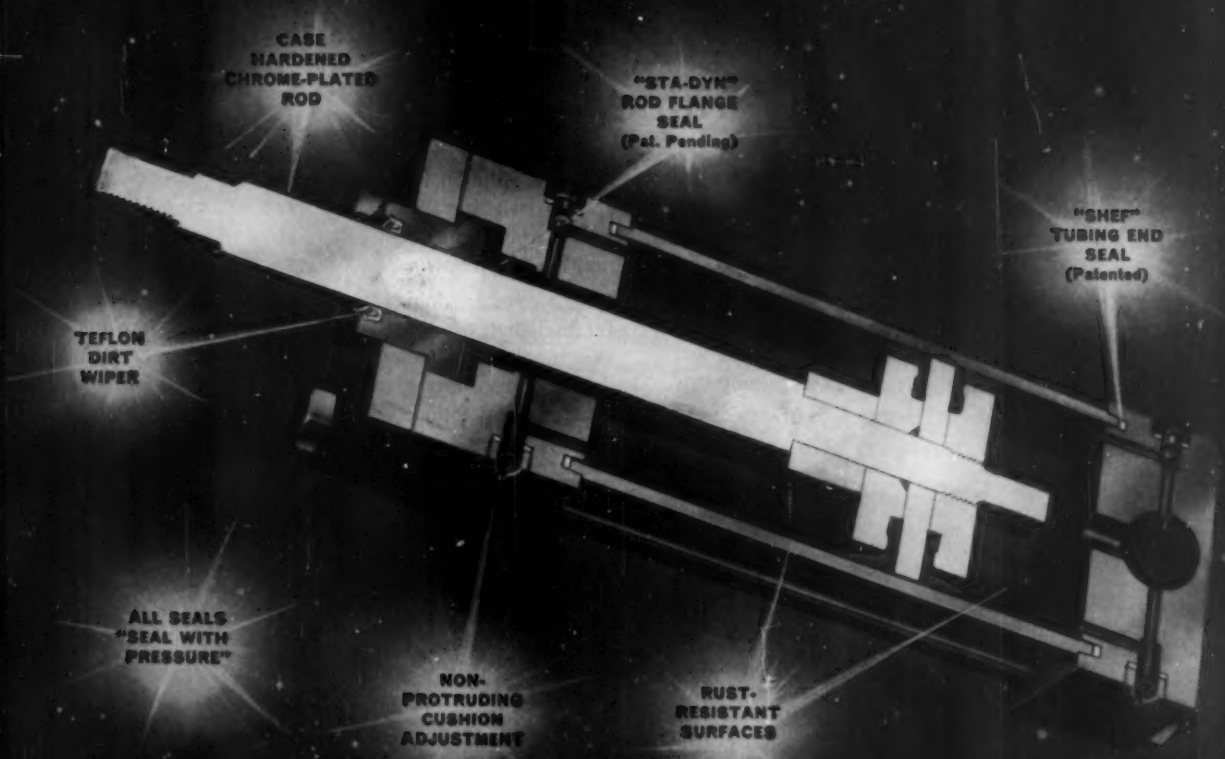
progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

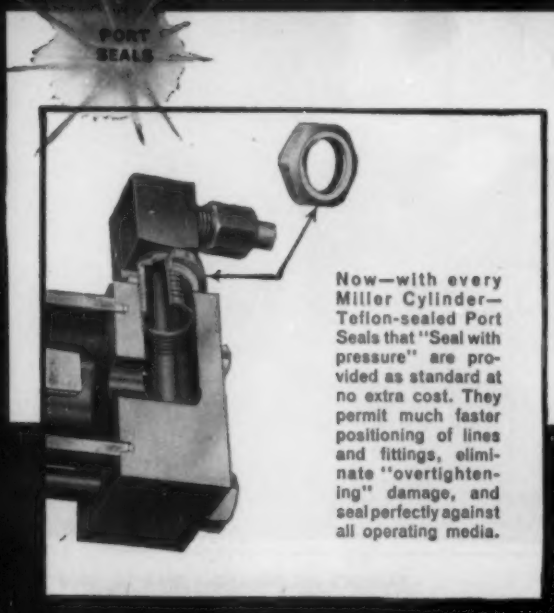
CIRCLE 38 ON READER SERVICE CARD

CIRCLE 39 ON READER SERVICE CARD→

Stellar RELIABILITY and ECONOMY


CASE HARDENED CHROME-PLATED ROD
"STA-DYN" ROD FLANGE SEAL (Pat. Pending)
"SHEF" TUBING END SEAL (Patented)
TEFLON DIRT WIPER
ALL SEALS "SEAL WITH PRESSURE"
NON-PROTRUDING CUSHION ADJUSTMENT
RUST-RESISTANT SURFACES

Miller AIR CYLINDERS



Now—with every Miller Cylinder—Teflon-sealed Port Seals that "Seal with pressure" are provided as standard at no extra cost. They permit much faster positioning of lines and fittings, eliminate "overtightening" damage, and seal perfectly against all operating media.

Here are eight more reasons why Miller Air Cylinders continue to be the most economical and reliable cylinders that money can buy. These stellar features—including the new port seals—are standard Miller construction—yours at no extra cost. Thus, they provide appreciable savings in original investment—*particularly for those who insist on "J. I. C." quality throughout.* Savings in operating costs are even greater, because these features are proven assurance of longer cylinder life, greater efficiency, reduced maintenance and downtime.

Specify "Miller" for greater reliability and economy! Write for bulletin.

MILLER FLUID POWER

7N018 York Road, Bensenville, Illinois

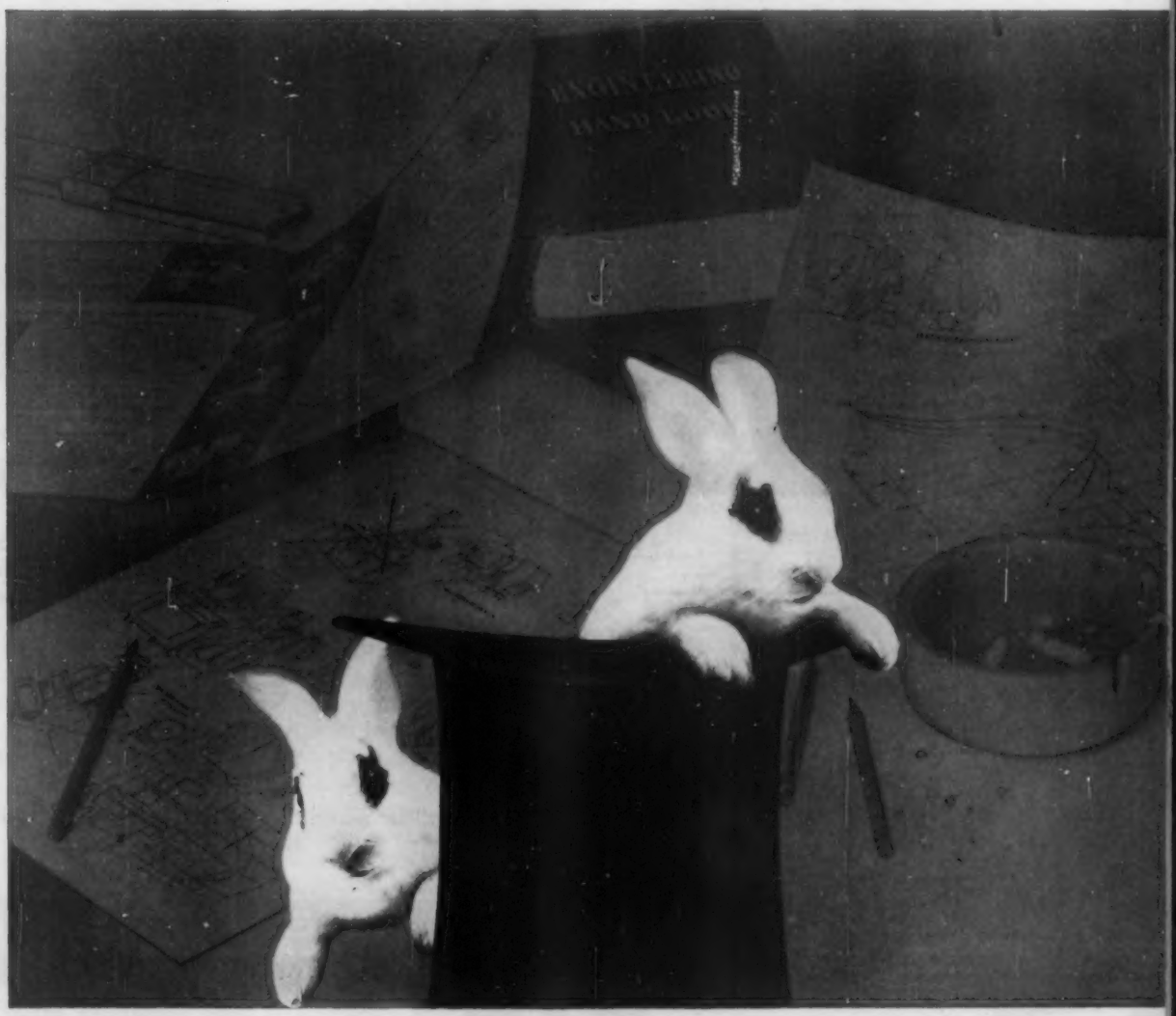
Bring out the FULL MAGIC of your own engineering know-how with Special REULAND Motors

Don't ever let a complicated drive requirement stymie your own ingenuity. If you have a design idea, go right ahead with it... leave the motor adaptation to Reuland.

Reuland cut its eye teeth in the motor business, many years ago, by supplying special motors for new design concepts. And, while our company now supplies many thousands of standard motors each year, we have never lost sight of the industry's continual need for something new.

Reuland's basic "Xpandable" design is ideally suited to special adaptation. For example, there are well over 2000 special designs in the Reuland Special Motor Library... one of which may very likely be close to something you may need right now.

Whether you are doing futuristic doodling... or designing for immediate production... cash in on your own creative designing talents. A single experimental motor, or a production run, will receive the same well known Reuland spirit of cooperation. Why not check into what we say.

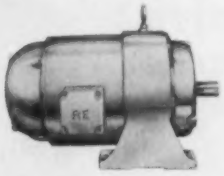


MULTI-DRIVE MOTOREDUCER

Shown here is a typical example of a Reuland multi-drive unit, as adapted for use on a screw conveyor bag filler machine. The primary motor turns the screw for high speed filling. For final, precision filling, a D. C. clutch cuts in the 128 r.pm. Motoreducer. Speed reduction ratios of as much as 100:1 are available.

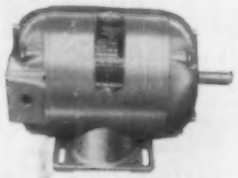
5-STAGE DRIVE CYCLE PACKAGE

A complete, five-stage operating cycle is handled by this one drive package... (1) 100 r.p.m. forward run, (2) immediate stop, (3) fluid-cushioned start again, (4) reverse direction and (5) return at 200 r.p.m. The complete cycle is accomplished by an internal fluid coupling...two-speed, reversing duty motor, gear reducer, and magnetic brake...*within one frame!*



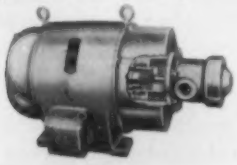
STALL DUTY TORQUE MOTORS

Reuland torque motors can be stalled or "locked" into a load with full current on. The units also automatically adjust their speed to intermittent load changes. Output torques can be changed, as desired, through the use of voltage varying devices. Available in ratings from ½ through 10 foot pounds...for maximum stalls of 5, 10, 20, 60 minute and *continuous.*



SPLINE COUPLED PUMP MOUNT MOTORS

Reuland spline-coupled hydraulic pump mount motors feature a direct connection between the pump and the motor's shaft... *inside the motor.* The installation is made by simply slipping the spline coupling onto the pump shaft...and attaching the pump to the endbell. The unit eliminates flexible couplings and platform mounts. Reduces mounting space almost 50%. Assures perfect alignment, automatically.

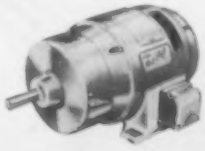


MACHINE TOOL MOTORS

These precision machine tool motors are a completely new type, especially made for the machine tool industry. They are compact in design and built to precise specifications like a fine tool. Their individual dynamic balancing...heavy duty ball bearings...low inertia, lightweight rotor...and even smooth-finished castings, make them a match for the most expensive machine tool.

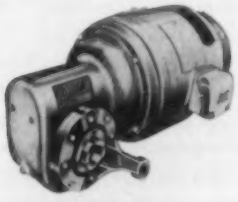
FLUID-SHAFT BRAKEMOTORS

Reuland Fluid-Shaft motors eliminate shocks and jerks and provide a smooth gradual, stepless method of load acceleration. Power is transmitted through an internal fluid coupling and all starting inertias are absorbed in a cushion of oil. The Reuland "doughnut" magnetic brake... mounted on the output side of the coupling ...permits extending the motor shaft right through for load hook-up.



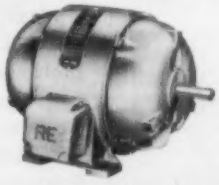
HOLLOWSHAFT WORM MOTOREDUCERS

This unique, right-angle Motoreducer features a *hollow shaft* that permits direct-coupling to equipment by merely inserting the drive shaft of the machine. No other mounting arrangement is required, except the torque arm which serves as an "anchor" for the Motoreducer. Eliminates the need for couplings, brackets, or belt and chain drives. Mounts in very tight areas.



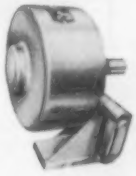
MULTI-SPEED MOTORS

Basic designs consist of three predetermined speed rating selections; 2-speeds, 3-speeds and 4-speeds. The motors are also available with three torque-horsepower-speed combinations. (1) Constant torque ...h.p. varies directly with r.p.m. (2) Variable Torque...h.p. variation is proportionate to the square of the speed, and (3) Constant horsepower...wherever h.p. need is constant regardless of operating speed.



DISC-TYPE MAGNETIC BRAKES

Reuland "through-shaft" magnetic brakes feature a fast and sure direct action principle. Levers and linkage are eliminated by a simple attraction and release action between the armature and "doughnut" type magnet. Available for use with all makes of motors in (1) *endbell* type, (2) *foot mounted* and (3) *foot mounted–complete with own bearings and shaft.*



MODERN POWER FOR MODERN-DAY PRODUCTS

...all in lightweight aluminum frames!

REULAND MOTORS

Our new general catalog will come in handy. Sent free on request. Describes the exclusive Reuland "Xpandable" design idea...Tells how you can benefit by using our free Special Motor Library.

REULAND ELECTRIC COMPANY

WESTERN DIVISION: *Alhambra, California*
EASTERN DIVISION: *Howell, Michigan*
Distributors in all principal cities

REFER TO SWEET'S PRODUCT DESIGN FILE, SECTION 5A

NEW!

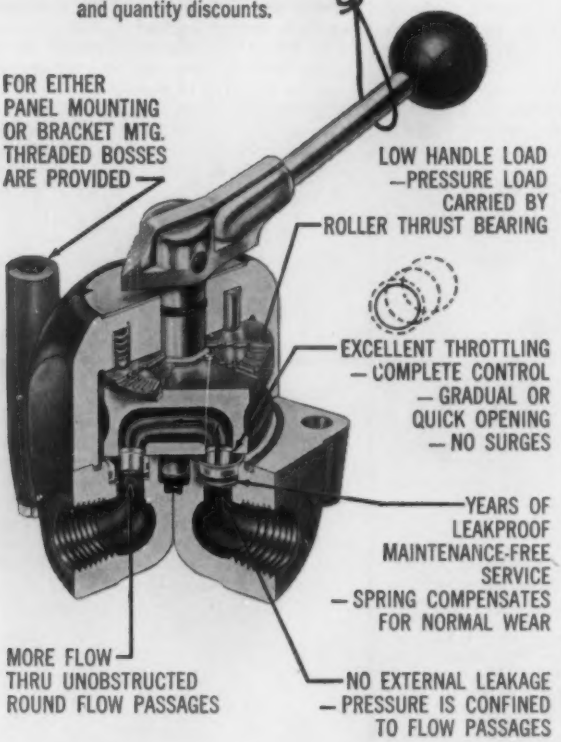
A "SHEAR-SEAL" VALVE

for LESS than a spool valve

RATED FOR 3000 P.S.I. OIL SYSTEMS

$65.00
List Price*
for a ¾" valve

*Less the usual O.E.M. and quantity discounts.


FOR EITHER PANEL MOUNTING OR BRACKET MTG. THREADED BOSSES ARE PROVIDED
LOW HANDLE LOAD —PRESSURE LOAD CARRIED BY ROLLER THRUST BEARING
EXCELLENT THROTTLING — COMPLETE CONTROL — GRADUAL OR QUICK OPENING — NO SURGES
YEARS OF LEAKPROOF MAINTENANCE-FREE SERVICE — SPRING COMPENSATES FOR NORMAL WEAR
MORE FLOW THRU UNOBSTRUCTED ROUND FLOW PASSAGES
NO EXTERNAL LEAKAGE — PRESSURE IS CONFINED TO FLOW PASSAGES

For complete data on this new valve and for information on all your valve requirements write for Catalog V-59-60

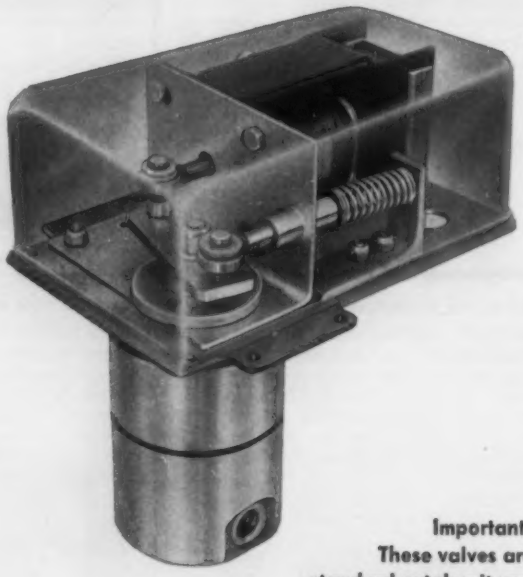
CONTROL VALVE DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

42 CIRCLE 42 ON READER SERVICE CARD

10,000 P.S.I. SOLENOID VALVES



Important: These valves are standard catalog items.

● They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

● Shut off and 4-way valves in ¼, ⅜ and ½ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).

Solenoids are available for 115, 230 and 460 volt A.C. operation.

● Long maintenance-free service is achieved through the leak-proof "Shear-Seal" design. Optically flat metal to metal sealing surfaces (of the self-aligning sealing rings and the mating rotor face) are protected by staying in constant intimate contact: flow is always through the center of the "Shear-Seals," never across sealing surfaces. Sealing qualities actually improve as the seals lap themselves to a more perfect fit with each valve operation. There is no external shaft leakage because the pressure is confined to the flow passages.

For complete data write for catalog S-10000.

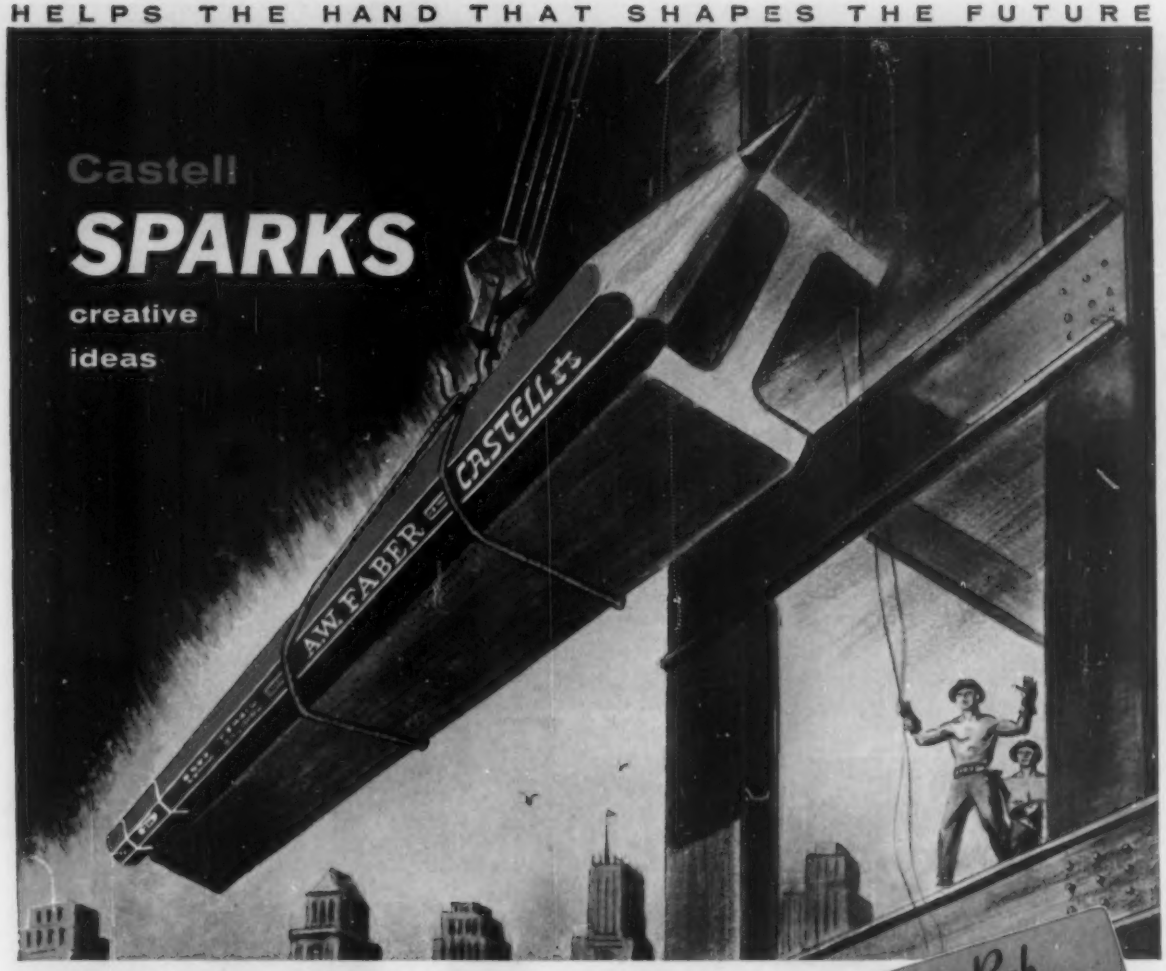
CONTROL VALVE DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

CIRCLE 1 ON READER SERVICE CARD

HELPS THE HAND THAT SHAPES THE FUTURE



The creative man's brain is awhirl. Instinctively his hand reaches for his CASTELL pencil. The brain child is locked within. Now it must be brought to life on a plane surface to conform to the nebulous image. CASTELL, the world's finest drawing pencil, is the trusted intermediary. Because it is itself conceived and produced with the care and skill of a precision instrument, CASTELL is the partner of progress the world over. To a creative man, CASTELL is an unquestioned fact of life.

#9000 CASTELL Pencil with world's finest natural graphite that tests out at more than 99% pure carbon. Exclusive microlette mills process this superb graphite into a drawing lead that lays down graphite-saturated non-feathering lines of intense opacity for cleaner, more durable originals and clearer, sharper prints. Extra strong lead takes needlepoint sharpness without breaking or splintering. Smooth, 100% grit-free consistently uniform pencil after pencil, in full range, 8B to 10H.

#9007 CASTELL Pencil with Eraser.

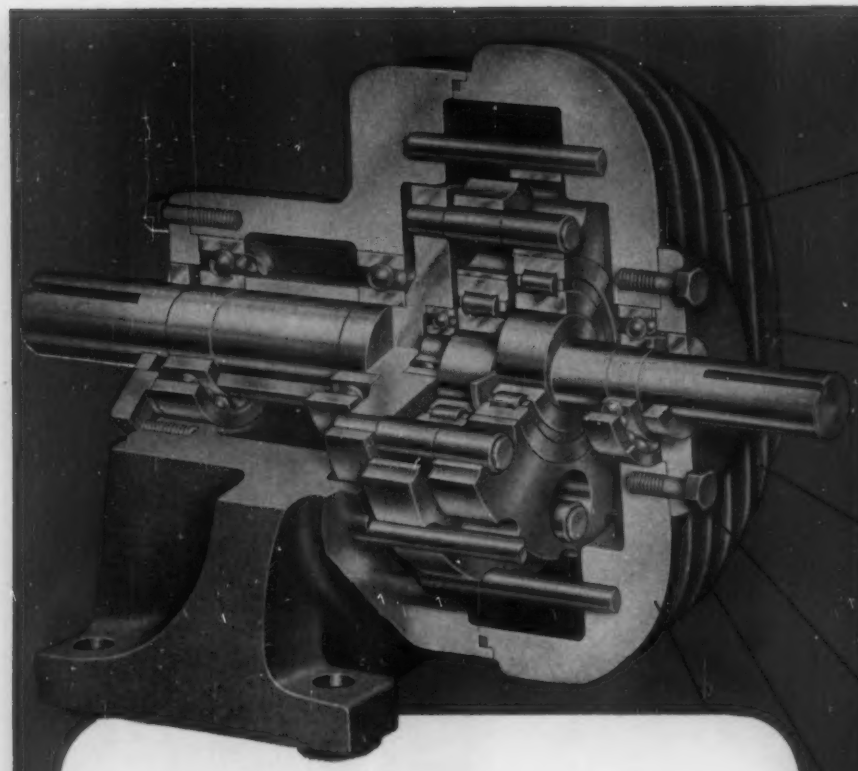
CASTELL Pencils and Leads draw perfectly on all surfaces, including Cronar and Mylar base films. Give graphite-saturated lines, easy to erase, no ghosting — excellent reproduction.

***CASTELL** Rubberless MAGIC-RUB ERASER soaks up graphite without abrading drawing surfaces, and residue rolls off. Leaves no "oil" stain or "ghost." Tests highest in ease of use, line removal and non-smudging. Tests first on Cronar and Mylar base films. For all papers and vellums.*

#9800SG CASTELL LOCKTITE TEL-A-GRADE Holder, perfectly balanced, lightweight, with new no-slip functional grip that lightens finger pressure without slipping, and relieves finger fatigue. Unique degree lead indicating device.

#9030 CASTELL Refill Lead, matching exactly #9000 pencil in quality and grading, degrees 7B to 10H, packed in reusable plastic tube with gold cap.
Many other styles and colors of CASTELL Pencils Holders and Refill Leads.

A.W.FABER-CASTELL 41-47 Dickerson Street, Newark 3, N. J.



NEW, COMPACT, HI-TORQUE *HI-RANGE* REDUCTION DRIVES

IDEAL FOR APPLICATIONS NOT POSSIBLE WITH OTHER TYPES OF REDUCERS... AND FOR STANDARD REQUIREMENTS.

HI-RANGE Cycloid-Type Reduction Drives are 40% to 60% smaller than other types of reducers with comparable ratings. They provide a wider range of torque—and pound for pound, a higher torque—than any other type of reducer... ranging from about 30 in.-lb. torque per pound of reducer weight to over 80 in.-lb. torque per pound. As a result, HI-RANGE units lend themselves extremely well to special applications and integral design. They are ideal where space or weight or both are important factors and where, in addition, high torque is required.

Black Tool Engineers are highly experienced in the design of reducers for special applications. They will be glad to consult with you on your reduction drive problems.

Write today for Brochure RD-200.

BLACK TOOL, INC.

1924 South Navajo Street
Denver 23, Colorado

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Fairbanks Nº 1

a scale, our first one.
an imagination of iron, brass, copper and lead,
fashioned in a New England workshop.
inanimate.

but it spoke—
a different kind of language,
of pounds and ounces and fractions thereof
and it spoke only the truth.

it felt—
the roundness of grain, the smoothness of marble,
the sweetness of candy and the authority of gold.

it heard—
the sound of life, babies newborn
it cradled them and recorded their growth
until pounds and ounces were replaced
by years and months.

it traveled—
by packet boat down the Mississippi,
by clipper ship to England,
The Sandwich Isles, the Indies,
South America and China.
better known throughout the world
than anything else made in America.

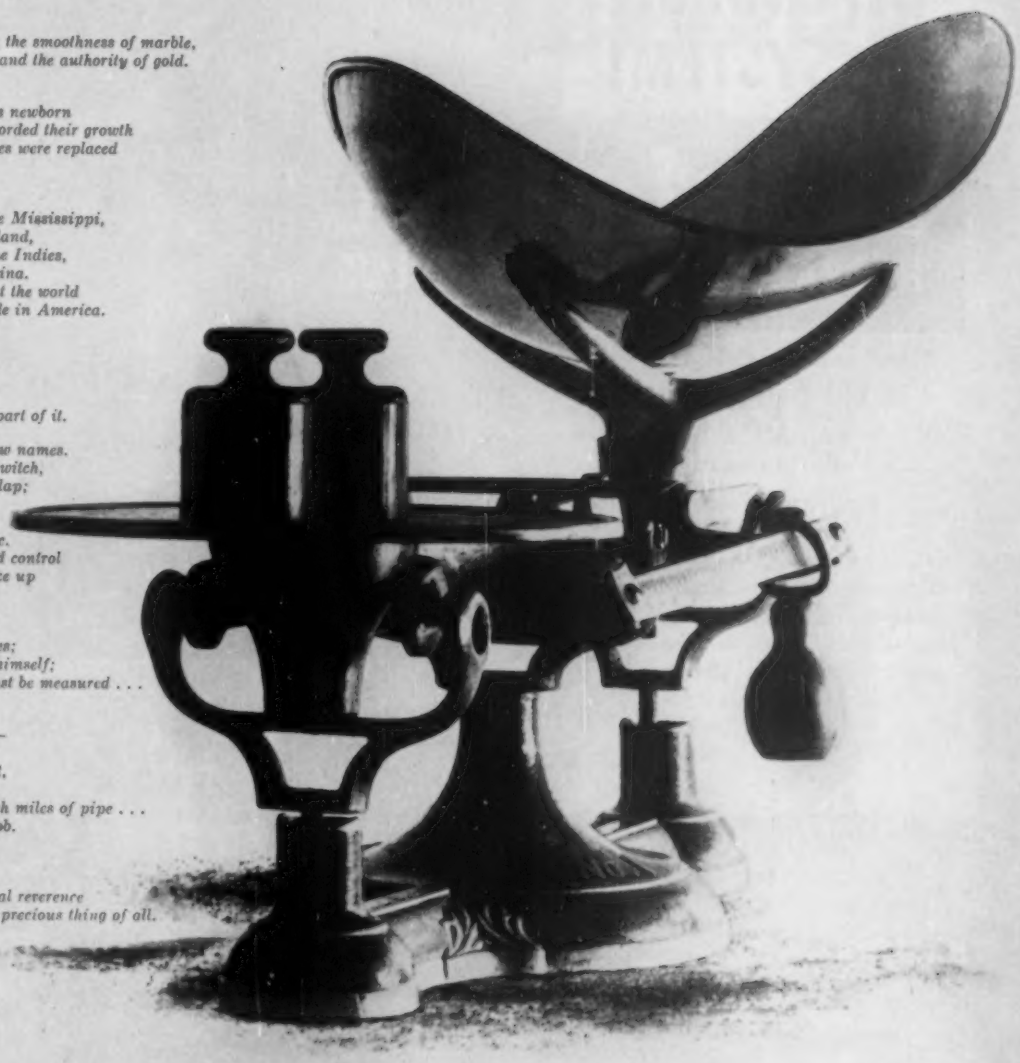
it was relied on
by farmers, merchants,
scientists and doctors.
it witnessed history;
influenced it and was part of it.

its descendants have new names.
floaxial dial, mercoid switch,
reed switch and cotton lap;
remote control,
printomatic,
electronic and levetronic.
all serve to evaluate and control
the substances that make up
the universe.

raw materials
or manufactured articles;
things unseen or man himself;
all have weight and must be measured . . .
our scales do the job.

and the new challenge—
weight in motion . . .
freight trains in transit,
trucks too busy to stop,
liquids coursing through miles of pipe . . .
our scales will do the job.

but this was our first—
Fairbanks No. 1
and we hold it in special reverence
for it weighed the most precious thing of all.
it weighed an idea.



Fairbanks, Morse

A MAJOR INDUSTRIAL COMPONENT OF FAIRBANKS WHITNEY CORPORATION, NEW YORK

Scales for heavy industry and for business; scales for science and for the home. Scales that weigh milligrams or millions of pounds. Scales that weigh missile fuel loads at Cape Canaveral; trucks on the Golden Gate Bridge; onions at your neighborhood grocer's . . . we make every kind of scale for every kind of purpose, including electronic scales. We are the Number 1 manufacturer of scales and automated weighing systems in the world.

If you have a problem where the careful calculation of weight is of vital importance, please write to Mr. Robert W. Kerr, President, Fairbanks, Morse & Co., 600 So. Michigan Ave., Chicago 5, Illinois.

THE KEY TO A DEPENDABLE SYSTEM!

Eastman
HYDRAULIC HOSE ASSEMBLIES

EASTMAN designs complete hydraulic operation for SCHRAMM Rotadrill

Valves mounted in three convenient banks for each outrigger, forward and reverse rotation of motor, slow down speed, rapid down speed and for breakout cylinder.

The cooperation of EASTMAN Engineering was enlisted in making the operation of this truck-mounted Schramm Rotadrill *completely hydraulic.*

Hydraulic power is delivered through EASTMAN Hydraulic Hose Assemblies to:

1. Three-Speed Reversible Rotation Head: Standard speeds—44, 65 and 120 r.p.m. with 26,500 inch pounds torque. 2. Cylinders controlling down feed, rapid feed and slow feed. 3. Controls for raising and lowering of mast. 4. Breakout Cylinder. 5. Hydraulic Winch and Hook. 6. Three Outriggers.

Dependable field service is assured through EASTMAN Two-Wire Braid High Pressure Hose with Permanently Attached Couplings providing a bond stronger than the hose itself.

Efficient power delivery through the extensive, multiple circuits of this rock-drilling rig is obtained through EASTMAN designed permanently attached hose assemblies which insure longer life and lower cost.

ENGINEERED FOR ENGINEERS BY ENGINEERS

Let EASTMAN Engineering assist you in planning the initial layout of your hydraulic system—for most efficient power delivery and lowest cost.

PERMANENTLY ATTACHED COUPLINGS
for 1, 2, and 3 wire braid rubber cover hose

REUSABLE COUPLINGS
for fabric cover hose

REUSABLE COUPLINGS
for rubber cover hose

CLAMP COUPLINGS
for 1, 2, and 3 wire braid rubber cover hose

Write today for Bulletin 100 and 200 on EASTMAN High, Medium and Low Pressure Hydraulic Hose Assemblies.

Eastman MANUFACTURING COMPANY
Dept. PE-5, MANITOWOC, WISCONSIN

CIRCLE 47 ON READER SERVICE CARD→

another Plus Value by NOPAK

NOPAK SMASHES

DESIGN BARRIER

with world's first SQUARE BARREL CLASS 7 CYLINDER

ACTUAL SIZE 1" DIAM. BY 3" STROKE

ALL SQUARE CONTOUR

The NOPAK Class 7 is the first volume produced cylinder to provide the spectacular advantages of the *complete all-square* design. Aligning the square heads with a square barrel results in four flush sides . . . no humps, no bumps, only clean, smooth lines throughout.

BLASTING OFF! at Booth 213!

Design Engineering Show!

NEW MOUNTING CONCEPT

Only NOPAK's exclusive Square Barrel can give you this unique mounting! Mounting holes can be drilled or tapped directly into cylinder tubing, either longitudinally or at right angles. Cylinder heads can be similarly utilized.

MODERN MATERIALS

Extruded and pressure-cast aluminum (hard anodized) set new standards of performance, durability and light weight.

MOST POWER PER POUND

Aluminum barrel . . . aluminum heads . . . no tie-rods . . . give the Class 7 cylinder the greatest power-weight ratio available.

MINIMUM SPACE

With or without heads, and tie rods eliminated, this Square Barrel cylinder can be built into your machine as an integral unit . . . *in less space than any competitive cylinder.*

VERSATILE, ADAPTABLE

Quick-change mounting attachments in various combinations of foot, flange, clevis or trunnion can be used to meet a wide range of application requirements with *one* basic cylinder.

CLEAN LINES

No tie-rods, no complex head locks, no uneven dirt-catching surfaces . . . make the NOPAK Class 7 Square Barrel a must for food processing, vending machinery, clinical equipment or any place where sanitary conditions or neat appearance are paramount.

STACK COMPACT

Because of their contour, Square Barrel cylinders can be stacked one above the other or mounted side by side in the smallest possible space.

Write for Catalog 107

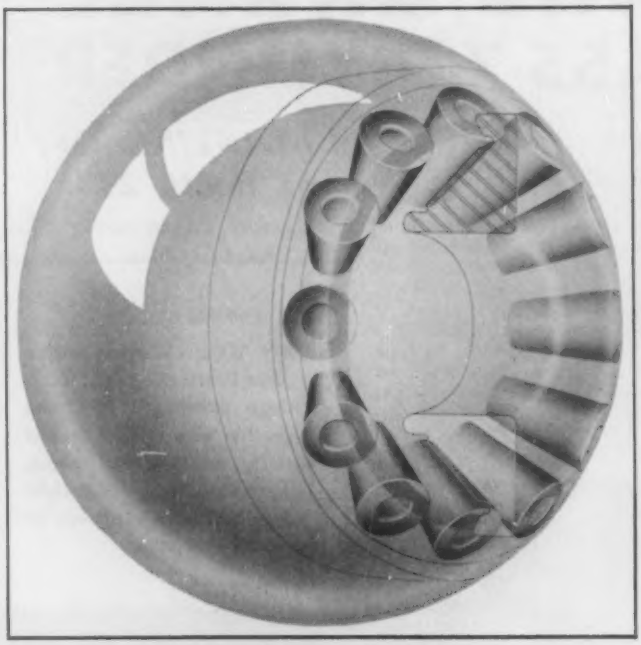
NOPAK *VALVES and CYLINDERS*

GALLAND-HENNING NOPAK DIVISION
2762 S. 31st Street
MILWAUKEE 46, WIS.

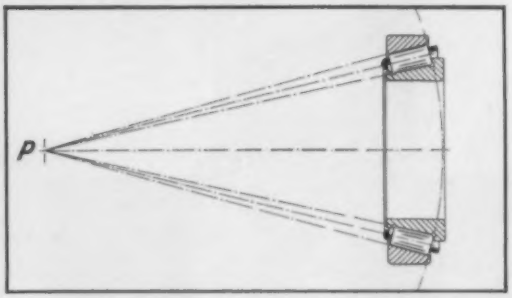
One in a series of technical reports by Bower

BEARING BRIEFINGS

SPHERICITY — ESSENTIAL TO MAXIMUM BEARING PERFORMANCE



When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.



True rolling of tapered bearing elements depends upon maintaining a true spherical radius during manufacture.

For a tapered roller bearing to achieve maximum performance, i.e., maximum life and capacity under load, it must have true sphericity — a condition of bearing geometry which permits true rolling of the tapered rollers in the raceway.

True rolling in tapered bearing elements is the result of maintaining a critical geometric relationship between the raceways and the contact surfaces of each roller. True rolling is essential to maximum performance. Without it, premature bearing failure is certain.

As engineers know, a tapered roller will describe a true circle when rolled on a plane surface. *It will always roll in this one path precisely, without sliding or skewing.* But to put true rolling to work in a bearing which can carry both heavy thrust and radial loads, it is essential that the rollers *and* the raceway have a true spherical radius, or sphericity. The drawing illustrates this condition.

If each roller in the bearing were to be extended in length, while retaining its taper, it would form a cone, terminating at point "P". All cones generated from all rollers would meet at point "P", which is also the center of the hypothetical sphere shown. The surface of the sphere would *touch all points on each roller's head!*

In effect, then, each roller's taper determines the radius of a hypothetical sphere whose surface, in turn, determines the correct contour for each roller head. Only when these conditions are satisfied in design, and when they are rigidly held during manufacture, will true rolling take place. In the manufacture of each Bower tapered roller bearing, sphericity is held within extremely narrow limits by means of special Bower-designed precision grinders. The consistent accuracy possible with these machines is one major reason why Bower roller bearings provide maximum performance under all speeds and loads up to the bearing's maximum rating.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

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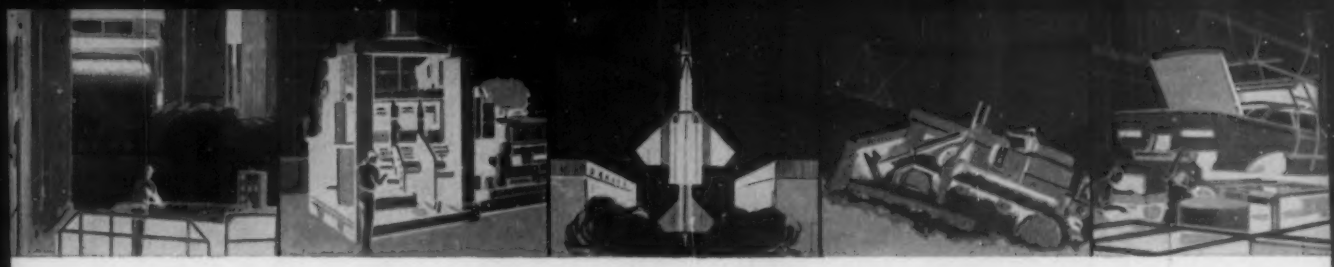
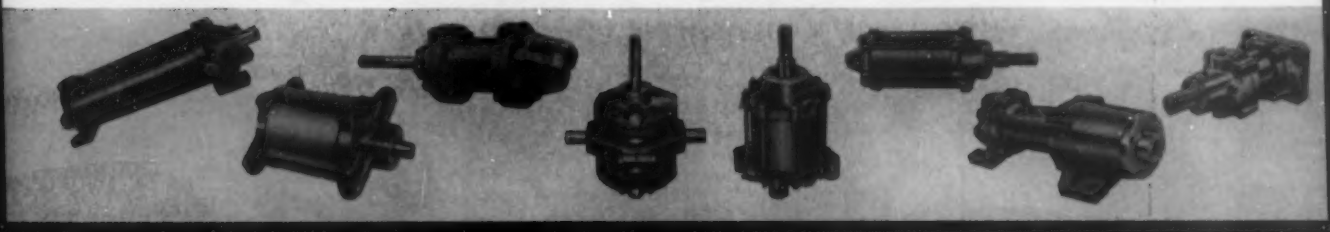
Experience proved in every major industry . . . ANKER-HOLTH

POWER CYLINDERS SAVE YOU TIME, TROUBLE AND MONEY

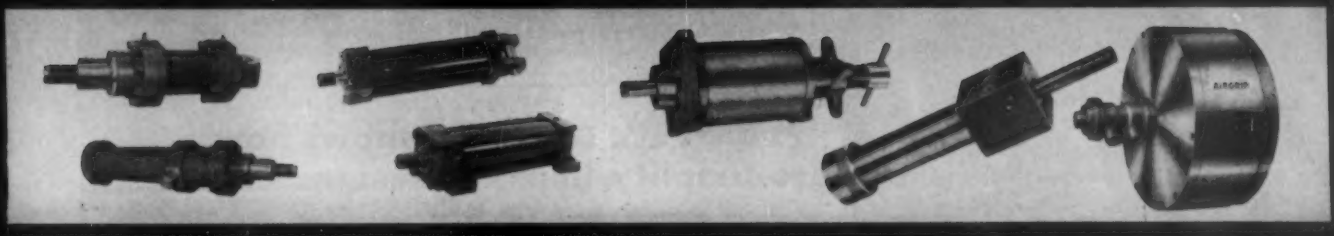


Select your needs

from the World's Widest Selection of Standard Cylinders



Check these compelling reasons why Anker-Holth air and hydraulic power cylinders save you time, trouble and money – widest selection of standard models | reliability through military accepted quality control program | simplified maintenance | all mountings available | bores 1" to 30" | strokes to 40' | built to JIC specifications | nationwide engineering service on call | complete facilities to engineer any power cylinder application outside the standard model.



Only a few models could be shown above

This free catalog shows them all

ANKER HOLTH

DIVISION, THE McDOWELL-WELLMAN COMPANIES

Send this

ANKER-HOLTH DIVISION
THE WELLMAN ENGINEERING COMPANY
2723 CONNOR STREET, PORT HURON, MICH., U. S. A. B-4

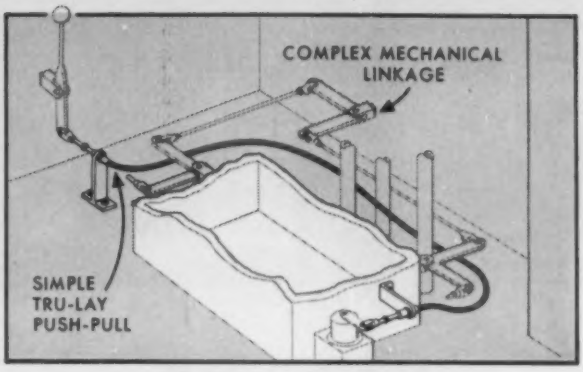
Name_____

Company_____

Address_____

TRU-LAY *PUSH*-PULL CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

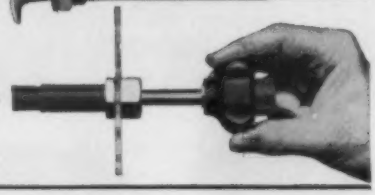
Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.



PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

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6800-E East Acco Street, Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn.

ACCO

CIRCLE 51 ON READER SERVICE CARD→

How Keystone QUALIFIES

as the leading independent producer of POWDER METAL PARTS

(over 150,000,000 of them annually)

We're told, often enough, that "There's a difference in dealing with Keystone."

In looking over some of the reasons-why, it occurs to us that because we were pioneers in powder metallurgy, perhaps we do have a special kind of perspective about our work. Over and beyond the essentials of a sound organization and production facilities to meet your requirements for almost any quantity of parts . . . on time, and at low cost . . . we have qualifications that are inseparable from the Keystone way of doing things.

One of them is *alert interest* in your problems (we learn more that way). Another: *creative approach* to your designs—which keeps us flexible. And one of special importance: *objective evaluation* —if application is unsound, we're frank to say so.

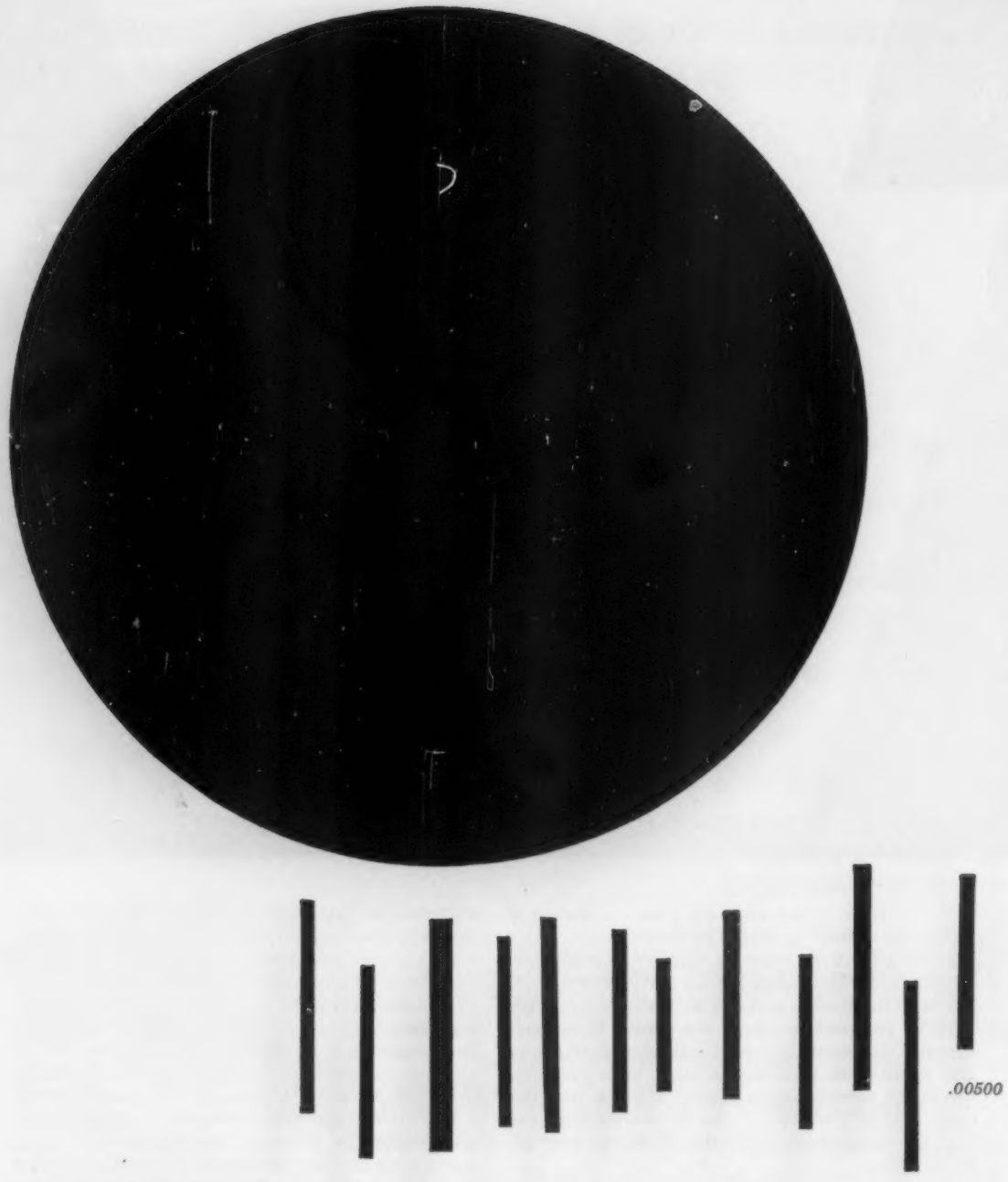
Perhaps we should conclude with *progressiveness.* Facts are, Keystone was first to produce commercially powder metal parts of alloy and stainless steels; first in the field to offer lower-than-commercial tolerance bearings, and first to provide corrosion-resistant finishes on iron powder parts.

For these and other reasons, a great many people turn to Keystone for the powder metal parts their businesses require. It's easily possible that you'd enjoy having us work for you, too. Write, and let's talk it over.

Keystone CARBON COMPANY

ST. MARYS, PA.

POWDERED METAL PARTS DIVISION



A MINIATURE BALL
COSTING A FRACTION OF ONE CENT
IS INSPECTED 6 DIFFERENT TIMES

AT THE WINSTED PRECISION BALL CORPORATION TO ENSURE RELIABILITY WITHIN MILLIONTHS OF AN INCH. THIS IS THE WAY WE DO THINGS AT WINSTED—CAREFULLY, PRECISELY—YET WE SHIP HUNDREDS OF THOUSANDS OF MINIATURE PRECISION BALLS EACH DAY. **SEND FOR ADDITIONAL INFORMATION TO:**

WINSTED PRECISION BALL CORPORATION, WINSTED, CONNECTICUT

...unusual features solve your cylinder problems

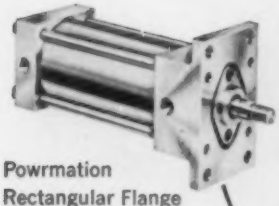
NEW HANNA *Powrmation* SERIES 1000 CYLINDERS

Pressure Safe Tube Seals

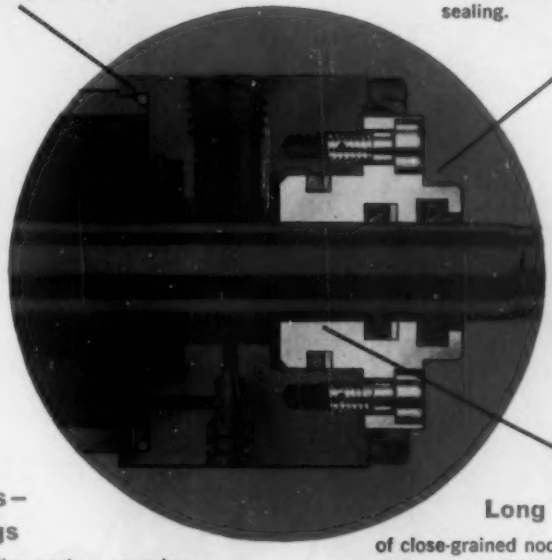
on the outside diameter of the tube create the most positive seal possible at all pressures from zero to maximum.

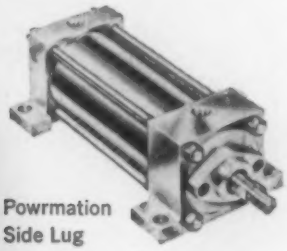
Fast Change Cartridge Gland

has leak-proof, low-friction rod seal and a rod wiper to remove dirt and to provide extra sealing.



Powrmation Rectangular Flange Rod End





Powrmation Side Lug Mounting

One Piece Steel Heads–Welded Steel Mountings

for maximum strength, perfect alignment . . . superior to bolted assembly. Mountings carry maximum cylinder load with ample safety margin.

Long Lubricated Bearing

of close-grained nodular iron with high graphitic content . . . one of the finest bearing materials. Rod seal on external side of bearing provides automatic bearing lubrication by hydraulic fluid or airborne lubricant.

POWRMATION CYLINDERS FOR AIR TO 250 PSI • HYDRAULIC TO 1000 PSI • BORES: 1½" THROUGH 14"

All good cylinders have "features" but few have a combination of really *Unusual* features that assure superior cylinder performance and dependability . . . New Hanna Powrmation Cylinders have. The features shown above and several others like: Unique, Check-Valve Cushions; Low Friction Nodular Iron Pistons; Positive Seal Block Vee Packings; Chrome Plated High Strength Steel Rod;—all these together with Hanna precision manufacturing and Hanna Field Engineering Service are the reasons why it will pay you to specify Powrmation Cylinders . . . they meet J.I.C. recommendations and have dimensional interchangeability.

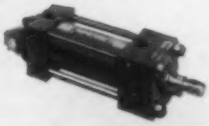
For Top Performance in Hydraulic Pressures

2000 PSI/3000 PSI Non Shock

HANNA POWRDRAULIC

Series 2000 CYLINDERS

Bores 1½" thru 8"



Write for Catalog 1000

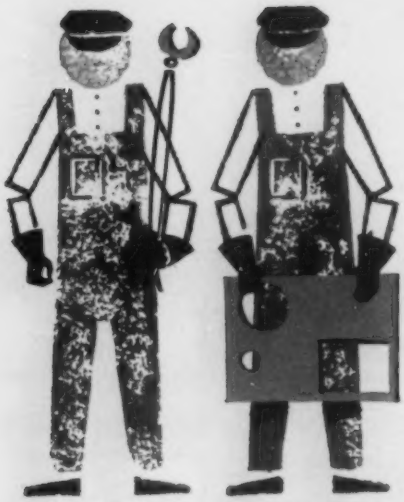
or ask Your Hanna Representative—see the Yellow Pages or Sweet's Design Catalog for his name

HANNA ENGINEERING WORKS

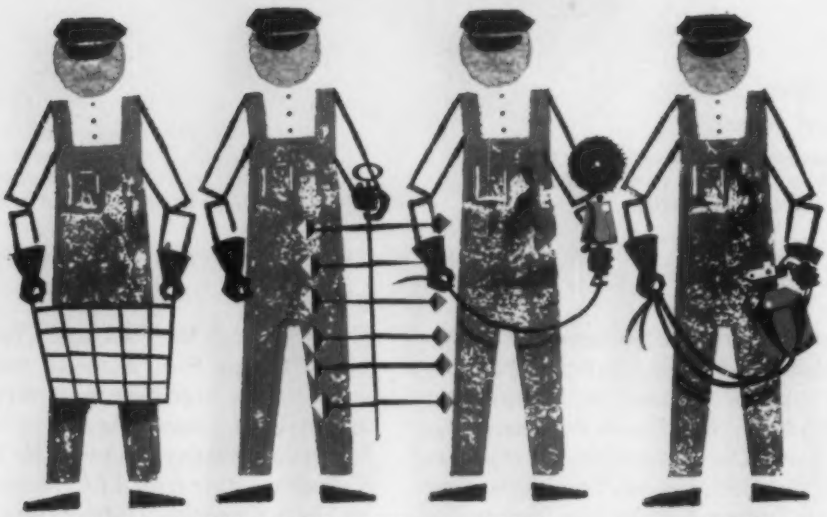
HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1763 Elston Avenue • Chicago 22, Illinois

ALL UNDER ONE ROOF AT BROWN-LIPE-CHAPIN



DIE CASTING METAL STAMPING



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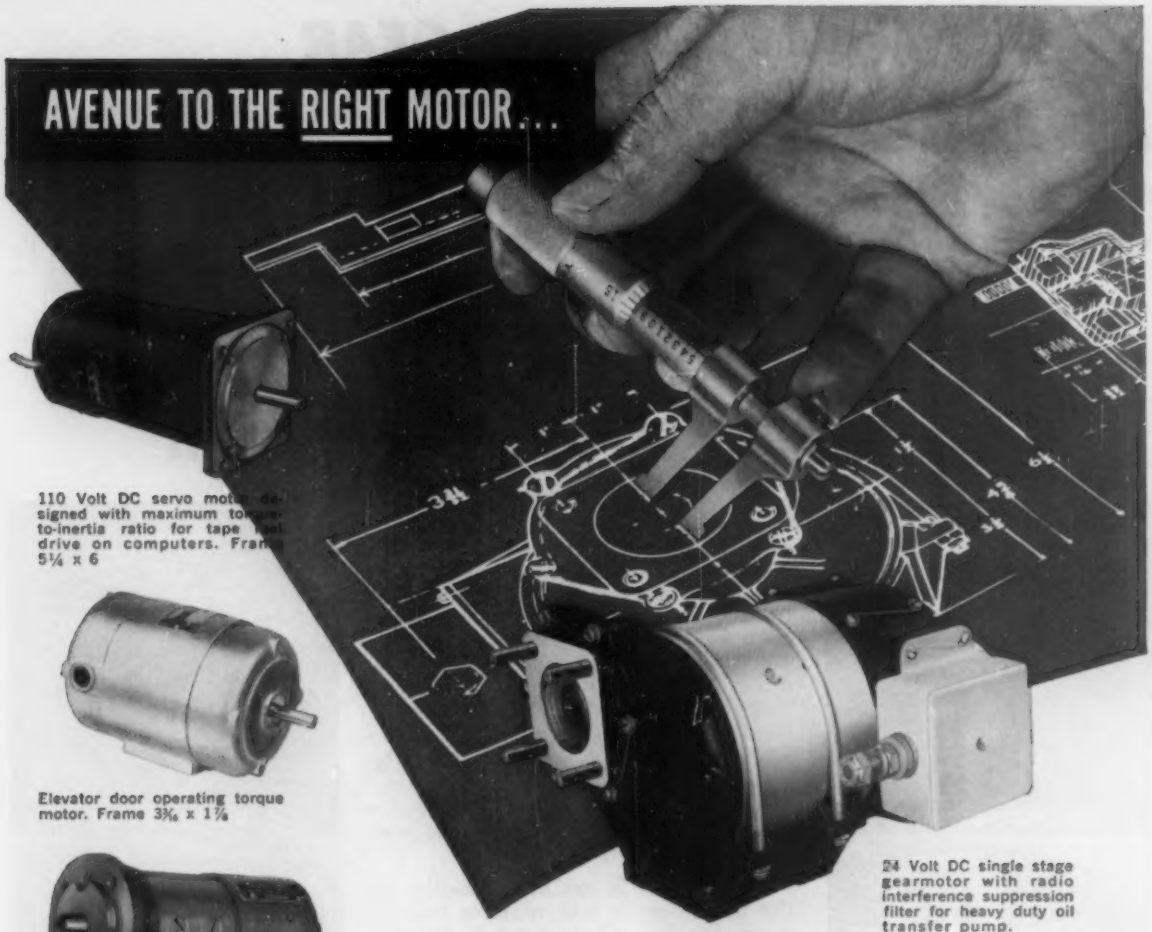

110 Volt DC servo motor designed with maximum torque-to-inertia ratio for tape reel drive on computers. Frame 5¼ x 6

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Into the design of a Lamb® motor goes our 45 years of specialized experience in powering aircraft components, industrial, commercial and domestic products.

Out of the design comes a motor having the dependability and smooth, efficient operation required for the exceptional performance of your product.

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provide greater flexibility in the design of your equipment

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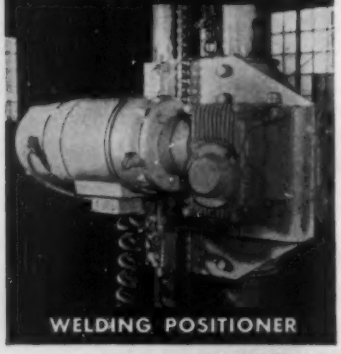
CONSTRUCTION EQUIPMENT



WELDING POSITIONER

Standard Cone-Drive hollow shaft speed reducers are available in four basic sizes (2, 2½, 3 and 3½ inch center distance units) to accommodate loads from fractional to 13 horsepower. They are built around the double-enveloping worm gear design and carry the same high ratings as standard Cone-Drive speed reducers.

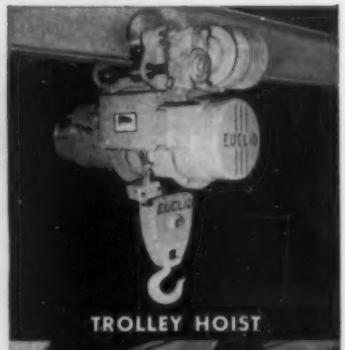
You, as a designer, will be particularly interested in the versatility of application and space savings made possible by the right angle design between input and output shafts.

The reducer is mounted directly on the driven shaft and requires only a simple bracket or torque arm to prevent it from rotating about the driven shaft.

Construction is rugged enough to permit floor or wall mounting of Cone-Drive hollow shaft reducers and "hanging" the driven shaft on it (in certain applications), eliminating pillow blocks or bearings. Larger-than-necessary taper roller bearings and heavy-duty castings make this possible.

If a motorized reducer is desired, a simple, standard bell housing can be furnished for NEMA C-type face motors. The need for expensive couplings is eliminated since a tang-type drive sleeve and suitably machined worms are provided. When a hollow-shaft speed reducer and face-mounted motor are combined, no bed plate or mounting arrangement is required. Pulleys, belts, sheaves, etc., that might be troublesome or difficult to install are also eliminated.

Ask for Bulletin CD-218.



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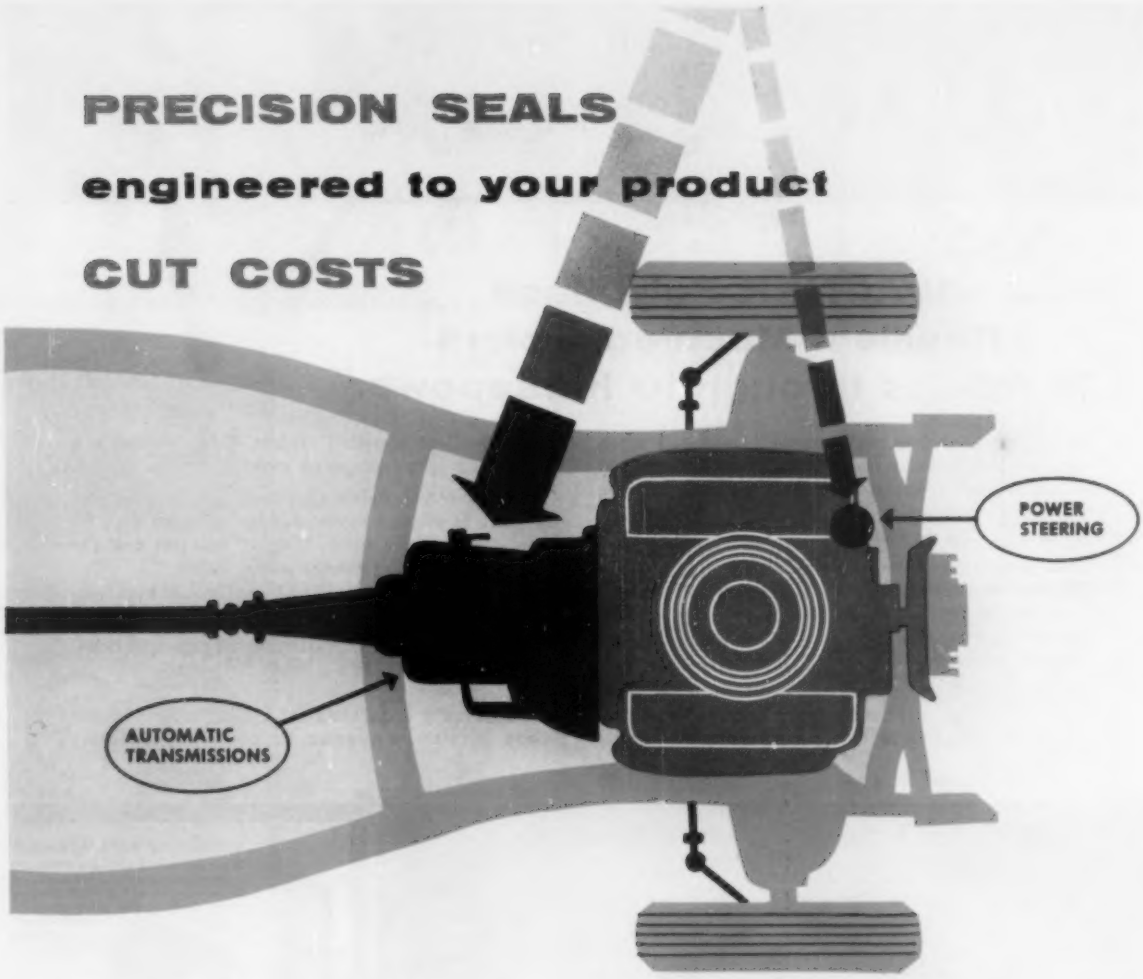

Problem Solving is a common occurence at Precision. One was the development of a universal compound for automatic transmissions and power steering systems. **The Solution** Precision Compound No. 6767—provided an "O" Ring with these characteristics. Suitable for all transmission fluids . . . particularly type "A" . . . long life over a temperature range of —40F to 300F . . . excellent resistance to cracking . . . low volume change . . . low compression set . . . high modulus. Precision creative research has reduced costs by producing the right "O" Ring for many manufacturers. You can benefit too, for the services of a Precision engineer are available to help you obtain the right product design and the right "O" Ring for it. Write or phone for his services today.

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Quiet...

WAGNER Polyphase Resilient Mounted Motors in ratings through 10 horsepower

Quiet, vibration-free performance is essential when motors are installed in areas where noise must be held to a minimum . . . in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is needed or wanted.

Such installations have created a need for larger polyphase motors that whisper while they work. Wagner has met this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

You certainly have applications that call for a smooth running motor, cushioned by resilient mountings. To make sure they're quiet, specify Wagner Polyphase Resilient Mounted Motors. Only Wagner can provide an entire range of ratings through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years . . . made the name Wagner one you can depend on in choosing electric motor drives.

Your nearby Wagner Sales Engineer can help you select the right motor to meet your requirements. There are Wagner branch offices in 32 principal cities.

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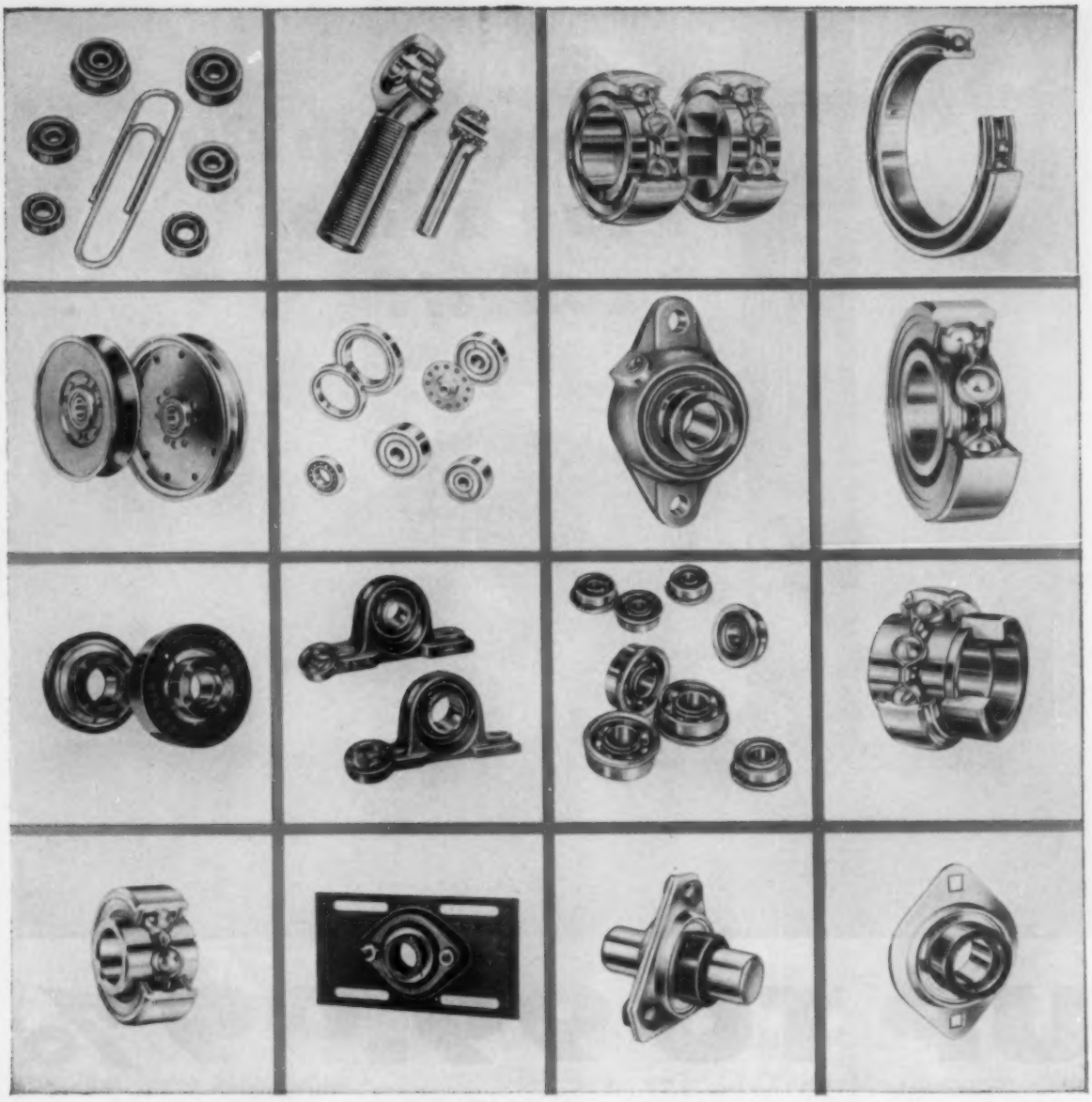
WM60-14

SLEEVE OR BALL BEARING
These motors are furnished with quiet running steel-backed babbitt-lined sleeve bearings of high load carrying capacity. Ball bearings can be supplied when desired.

CEILING, SIDEWALL OR HORIZONTAL MOUNTING
You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. Motor stays dripproof.

NEOPRENE CUSHIONING RING
Annular mountings, of oil-resistant neoprene bonded to steel rings, cushion the motor in its cradle base to absorb the small amount of vibration that remains in the most carefully balanced motor.



Sixteen clues on why designers look to Fafnir for selection in ball bearings!

You won't find a wider selection of precision ball bearings anywhere! Fafnir makes over 10,000 types and sizes. They range from miniature bearings (upper left) to 60-pound pillow blocks—and cover requirements in every major industry.

And the family keeps growing! The sixteen bearing developments above are among the more recent additions — and include (second from top at right) bearings with Fafnir's newly-designed rolled-in Plya-Seals that prevent seal loosening or push-in.

Also shown are rubber-cushioned ball bearings for air conditioning equipment, bearings for farm equipment, and special-precision aircraft types, an industry "first". Whatever *your* ball bearing needs, you'll find Fafnir can meet them.

Write for full information. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS
Progress in motion

CIRCLE 59 ON READER SERVICE CARD

UP TO 99.99%

if it uses WESTERN FELT!

Such efficiency is possible in a Hersey reverse-jet filter with particle size of 5 microns and a pressure drop of ½ inch of water.

Felt can be used to filter solids from solids, solids from liquids, or solids from gases. It is used effectively in fuel filters, air filters, chemical filters, respirators, or dust collectors.

Microscopic barbs on the live fibers of Felt make felt the ideal filtering medium. These scales collect and hold dust particles. They also encourage "build-up" or caking which actually increases filter efficiency. At the same time, their natural interlocking action holds fibers tightly together, through years of flexing.

For helpful engineering information on filtration felts, write

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MANUFACTURERS AND CUTTERS OF WOOL FELTS

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With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

CIRCLE 61 ON READER SERVICE CARD 61

CASE HISTORIES
U.S. AIR FORCE
Special high-temperature, full complement N/D ball bearing, made of cobalt base alloy, operates successfully at high temperature with no need for lubricant protection!

Photo: Courtesy Stratos Division, Fairchild Engine and Airplane Corp.

Special Alloy Ball Bearings keep Butterfly Valve modulating at 900° F.!

CUSTOMER PROBLEM:
Require highly heat-resistant ball bearings for butterfly valve which modulates 900° F. hot air blast in turbine air bleed. Despite radial loads up to 300 lbs., shaft must turn effortlessly through 65°.

SOLUTION:
New Departure Sales Engineers, cooperating with Stratos, manufacturer of the auxiliary power turbine, recommended N/D's special aircraft ball bearing of cast cobalt base alloy for this critical application. These bearings were selected for their ability to withstand extremely high temperatures without deterioration.

Extensive testing proved that this N/D equipped modulating system, currently used on the Lockheed Hercules C-130A, military transport, operates at required standards of performance and reliability . . . and without lubrication! In addition, other New Departure ball bearings, selected for their unsurpassed reliability, are used to support the turbine main shaft which operates at 45,000 rpm.

If you're looking for bearings that operate efficiently at unusually high temperatures and speeds, contact your local N/D Sales Engineer. For additional information call or write New Departure Division, General Motors Corporation, Bristol, Connecticut.

DON'T MISS N/D'S EXHIBIT!
BOOTH 633
DESIGN ENGINEERING SHOW — MAY 23 - 26

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

R_x for Reliability

Reliability is defined as "the probability of performing without failure a specific function under given conditions for a specific period of time." Back in 1858, Oliver Wendell Holmes wrote of a chaise so designed that it *couldn't* break down; it *had to* wear out. He called the design "logical"; we submit it's the best example of reliability engineering we could find to epitomize the objectives of the special report in this issue. — EJT

the Deacon's Masterpiece or, the wonderful "one-hoss shay" a logical story

Have you heard of the wonderful one-hoss shay,
That was built in such a logical way
It ran a hundred years to a day,
And then, of a sudden, it — ah, but stay,
I'll tell you what happened without delay:
Scaring the parson into fits,
Frightening people out of their wits —
Have you ever heard of that, I say?

Seventeen hundred and fifty-five.
Georgius Secundus was then alive —
Snuffy old drone from the German hive.
That was the year when Lisbon-town
Saw the earth open and gulp her down,
and Braddock's army was done so brown,
Left without a scalp to its crown.
It was on the terrible Earthquake day
That the Deacon finished the one-hoss shay.

Now in building of chaises, I'll tell you what,
There is always somewhere a weakest spot —
In hub, tire, felloe, in spring or thill,
In panel, or crossbar, or floor, or sill,
In screw, bolt, throughbrace — lurking still,
Find it somewhere you must and will —
Above or below, or within or without —
And that's the reason, beyond a doubt,
That a chaise breaks down, but doesn't wear out.

But the Deacon swore (as Deacons do,
With an "I dew vum," or an "I tell yeou")
He would build one shay to beat the taown
'N' the keounty 'n' all the kentry raoun';
It should be so built that it couldn' break daown;
"Fur", said the Deacon, " 'I's mighty plain
Thut the weakes' place mus' stand the strain;
'N' the way t' fix it, uz I maintain, is only jest
T' make that place uz strong uz the rest."

So the Deacon inquired of the village folk
Where he could find the strongest oak,
That couldn't be split nor bent nor broke —
That was for spokes and floor and sills;
He sent for lancewood to make the thills;
The crossbars were ash, from the straightest trees;
The panels of white-wood, that cuts like cheese,
But lasts like iron for things like these;
The hubs of logs from the "Settler's ellum,"
Last of its timber — they couldn't sell 'em —
Never an axe had seen their chips,
And the wedges flew from between their lips,
Their blunt ends frizzled like celery-tips;
Step and prop-iron, bolt and screw,
Spring, tire, axle, and linchpin too,
Steel of the finest, bright and blue;
Thoroughbrece, bison-skin, thick and wide;
Boot, top, dasher, from tough old hide
Found in the pit when the tanner died.
That was the way he "put her through."
"There!" said the Deacon, "naow she'll dew."

Do! I tell you, I rather guess
She was a wonder, and nothing less!
Colts grew horses, beards turned gray,
Deacon and deaconess dropped away,
Children and grandchildren — where were they?
But there stood the stout old one-hoss shay
As fresh as on Lisbon-earthquake day!

Eighteen Hundred; — it came and found
The Deacon's masterpiece strong and sound.
Eighten hundred increased by ten; —
"Hahnsum kerridge" they called it then.
Eighteen hundred and twenty came; —
Running as usual; much the same.
Thirty and forty at last arrive,
And then came fifty, and fifty-five.

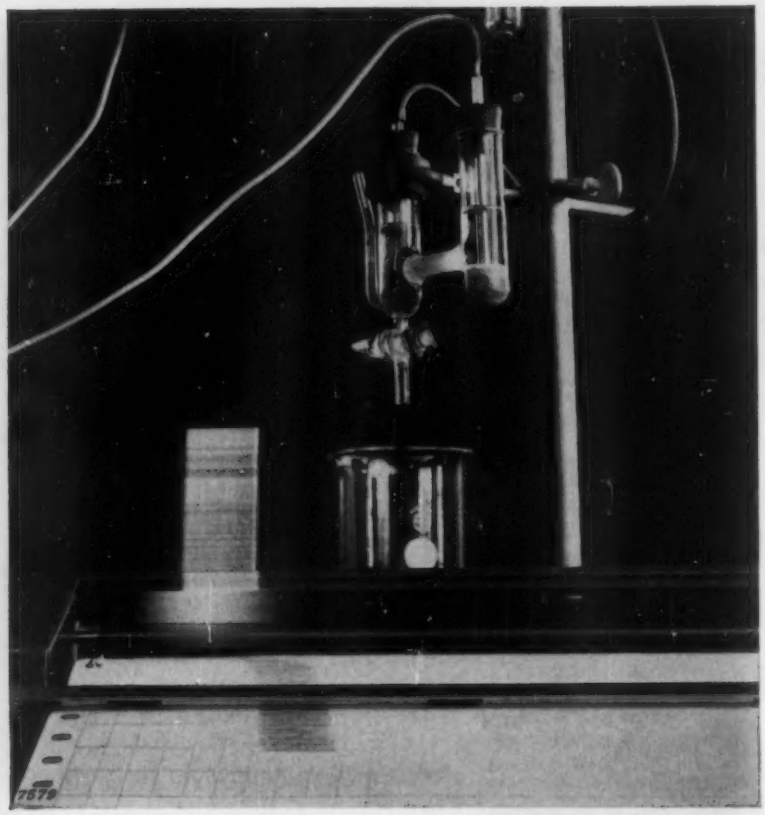
Little of all we value here
Wakes on the morn of its hundredth year
Without both feeling and looking queer.
In fact, there's nothing that keeps its youth,
As far as I know, but a free and truth..
(This is a moral that runs at large;
Take it. — You're welcome. — No extra charge.)

First of November — the Earthquake day:
There are traces of age in the one-hoss shay;
A general flavor of mild decay,
But nothing local, as one may say.
There couldn't be — for the Deacon's art
Had made it so like in every part
That there wasn't a chance for one to start.
For the wheels were just as strong as the thills.
And the floor was just as strong as the sills,
And the panels just as strong as the floor,
And the whipple-tree neither less nor more,
And the back crossbar as strong as the fore,
And spring and axle and hub encore.
And yet, as a whole, it is past a doubt
In another hour it will be worn out!

First of November, 'Fifty-five!
This morning the parson takes a drive.
Now, small boys, get out of the way!
Here comes the wonderful one-hoss shay,
Drawn by a rat-tailed, ewe-necked bay.
"Huddup!" said the parson. — Off went they.

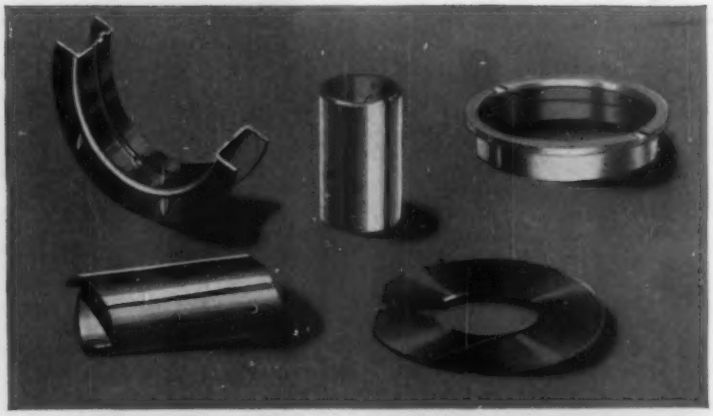
The parson was working on his Sunday's text;
Had got to the fifthly, and stopped perplexed
At what the — Moses — was coming next.
All at once the horse stood still,
Close by the meet'n'-house on the hill.
First a shiver, and then a thrill,
Then something decidedly like a spill,
And the parson was sitting upon a rock,
At half-past nine by the meet'n'-house clock —
Just the hour of the Earthquake shock!
What do you think the parson found,
When he got up and stared around!
The poor old chaise in a heap or mound,
As if it had been to the mill and ground!
You see, of course, if you're not a dunce,
How it went to pieces all at once —
All at once, and nothing first,
Just as bubbles do when they burst.
End of the wonderful one-hoss shay —
Logic is logic, that's all I say.

ANALYTIC "BLOODHOUND" SNIFFS OUT SECRETS OF BEARING CORROSION



WE USE THIS HYPERSENSITIVE DEVICE TO TRACK DOWN ENGINE BEARING CORROSION TO ITS SOURCE. This instrument needs only a minute fragment of metal for accurate analysis. Consequently, engine bearing corrosion can be traced from its beginning through complete destruction of the bearing surface. Because test variables are minimized, Federal-Mogul engineers can accurately relate degree of corrosion to specific engine operating conditions. This analytical tool is in continual use in our laboratory, assisting research on many different projects. Prevention of corrosion and development of new bearing alloys are high on the list!

SUCCESSFUL BEARING PERFORMANCE depends on selecting the proper alloy for the operating conditions to be met. Federal-Mogul engineers have had years of experience with bearings and applications of all kinds . . . and this wealth of knowledge is available to bearings users. This is one reason why F-M sleeve bearings, precision thrust washers, formed bushings, and low-cost spacers are chosen for use in virtually everything from baby buggies to heavy industrial cranes.



There's much valuable data in our Design Guides on sleeve bearings, thrust washers and bushings; and in our brochure on spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings
bushings-spacers
thrust washers

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

PRODUCT ENGINEERING SPECIAL REPORT

a manual of Reliability

A fourth "R" has entered our ken in the past few years. It's R, for Reliability. And with it has grown an entire science, as well as a new profession—that of reliability engineer.

Government specifications and requests for bids increasingly include reliability requirements, and indications are that all military products will soon be purchased on this basis. Though led by the military the concept has applications in all products—because the reliable product builds acceptance in the market place.

Responsibility for reliability centers squarely in the engineering department. Reliability must be designed in; no other department can build it in. Because the problem is so basically an engineering one, we here provide a handbook of principles. It is based on personal study of the reliability departments or groups in leading companies, particularly missile and component makers; on interviews with dozens of men charged with this responsibility, with members of control committees and with engineering executives; and on supplementary facts from a nationwide survey.

Emphasis in this report has been placed on mechanical reliability. The statistical approach has been de-emphasized and the jargon explained. Again we present the "facts behind the fad." ■

E J TANGERMAN, *editor*

in this report . . .

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DEAN ZAUMSEIL, product manager, adjustable-speed drives

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KENNETH E. COCHRAN, chief, Reliability Engineering Section

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what is Reliability

Reliable is an old and familiar, if somewhat tenuous, word. Webster offers such synonyms as "dependable" and "trustworthy." The mental picture created is of something solid, stolid and unglamorous—but sturdy like an old retainer or a cast-iron stove. Industry has from the beginning turned out products called reliable, and some of them really were—by massive over-design.

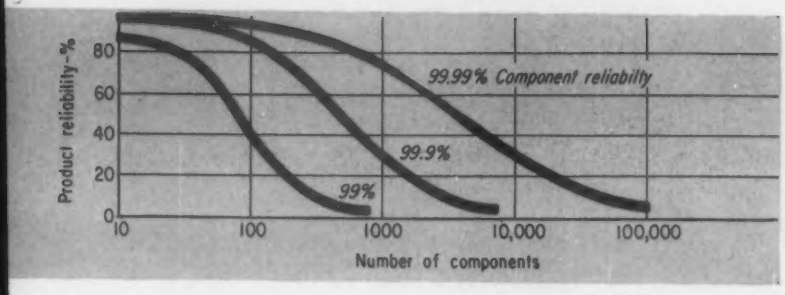
Then cost accounting became popular, and we saved money by designing for a smaller factor of safety. Next came planned obsolescence, and reliability began to go. Preventive maintenance and quality control helped, but not enough. Now, products have to be more automatic, faster, smaller—and this increased complexity is making reliability—the Big R—a major design problem.

Reliability is the one performance characteristic that the user can measure easily and objectively. And recently, he has been measuring it, too, and changing his buying habits to get it. He has come to call telephones, refrigerators, diesel engines, trucks, motors and pumps reliable—they operate long periods of time without attention. TV sets, radios and automobiles are less reliable, because they fail at crucial times, even with preventive maintenance.

There has been no real standard of reliability, either by industry or by makers. Higher cost doesn't guarantee higher reliability; neither does better reputation. Meanwhile, more and more complexity is the trend, and products become more and more sophisticated, complicated and sensitive. It took the missile, however, to tear things wide open. Here was an extremely sensitive and complex device that had to withstand road-hauling into position, stand by indefinitely before use, and fire instantly on demand. "Relatively high reliability" and similar amorphous terms were no good; the reliability had to be measured, established and proved. And there could be no man —"the finest 160-lb servo system ever devised"—to make up for malfunctions. *Every part had to function perfectly for and at the required time.*

This is being achieved—in missiles. Reliability is now measurable and can be stated in mathematical terms. For the first time, it is both a qualitative and quantitative concept, so successful that the military is spreading it to all elements of missile systems, whether manned or not, and to aircraft and other weapons systems. Industry is taking it up for even broader application; major companies have extensive programs. Reliability is becoming as important a criterion as efficiency, speed, accuracy or other performance factors—not only in consumer products, but in capital goods as well.

Why? Because a good reliability program cuts headaches and saves money. In our increasingly automated



AVALANCHE EFFECT is what happens to product reliability as the number of components increases—shown here for three levels of component reliability.

civilization, it is essential to make products right in the first place—repairs, when they can be made, are too costly.

Often, it isn't the complex element that causes troubles but the simple one; a 10-cent resistor can—and has—aborted the flight of a 300,000-part, million-dollar missile. In fact, much of the common loss of reliability isn't in parts, but in faulty joints—electrical, hydraulic, mechanical.

A LITTLE HISTORY

During World War II, 60% of airborne equipment shipped to the Far East was damaged on arrival, and 50% of the spares and equipment in storage became unserviceable before they were ever used. The Air Force was barely able to get 20 hr of trouble-free operation from the electronic gear on bombers. In 1949, about 70% of Navy electronic equipment was not operating properly.

Thus it is no surprise that on Dec 7, 1950, the Air Force formed an *ad hoc* Group on Reliability of Electronic Equipment, to study the whole situation and recommend measures that would increase the reliability of equipment and reduce maintenance. In April, 1951, the Navy began a lengthy study on radio tubes; the Army, two months later. In 1952, Autonetics set up a weed-out process that rejected 45% but improved reliability by an order of magnitude.

By late 1952, the Dept of Defense was so concerned with the problem that it established the Advisory Group on Reliability of Electronic Equipment (AGREE). RCA published a report on failure probability in October, 1956 (TR-1100), which gave measured failure rates of components; in June of the next year, AGREE published its first report on reliability. This included minimum acceptability limits, requirements for R tests, effect of storage on reliability, and the like.

Thus, the basic concept of quantitative reliability was born out of difficulty with electronic elements, mainly tubes, by the military. The benign environments of domestic radio bore no relationship to the tougher environments of airborne equipment and the really severe ones of missiles. Tubes have now been vastly improved; transistors have shown high reliability in many former tube functions; capacitors and resistors have been similarly improved. Relays are still culprits, but are being improved.

Meanwhile, mechanical structures were becoming much more complex, and they presented much more difficult problems. Electronic systems are easily breadboarded and in this form are near enough to the final equipment so that they can be R-tested, simply and quickly, under operating conditions.

Not so with mechanical systems. The "breadboard" model must be a very accurate one—practically a working model to final specs—if tests are to mean anything.

continued, next page

THE CASE OF THE ERRANT GYRO . . .

■ A certain missile made a good record in R & D flight tests. Many changes were made to improve productivity and reliability as the missile went into production, but certain of the gyros began to fail in the field. It was found that factory rejection rate on these same units was so high that it was difficult to supply the production line, let alone produce the abnormal quantity of spares for field units because of failures there.

Reliability personnel, through their design-review procedures, were recommending changes and thorough testing of these changes. But factory personnel insisted there was no time for deep analysis or test programs on changes; they gambled instead that their modifications would work. Factory rejection rate became so high that production was halted. The engineers made an emergency fix and the line was restarted. But this fix made other problems, so the line was halted again. And so on, for three complete cycles, while the reliability personnel kept urging: "Take a little extra time and do it right; stop cutting corners, and prove out the fix. At least start a concurrent test program in case the fix isn't optimum."

The mechanical design supervisor on gyros refused to consider these suggestions. He argued that all available gyros were needed on the line; no spares were available for tests. Meanwhile, field failures rose so high that the customer refused to accept more missiles until the gyro problem was solved. Result: an emergency meeting, with the general manager demanding to know who'd started the panic. After a look at the evidence, he ordered that design changes be made in accordance with recommendations of the reliability group. The fix proved successful, and the contract was completed. Subsequently, the general manager ruled that Reliability design-review recommendations be considered official, that they be on a par with those of Design, Production and Quality Control, and that all changes must be OK'd by Reliability before becoming final.

This case history illustrates:

1. Reliability people have a unique understanding of safety margins, conservative design, and seriousness of risks that teaches the importance of proving out a new design.

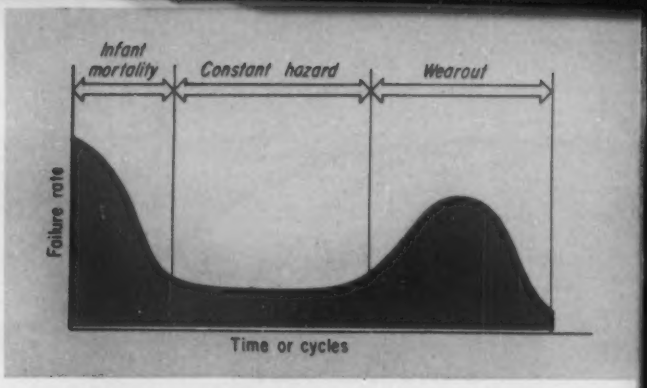
2. Reliability people have access to, and the ability to interpret, failure information that will provide a basis for correction at the proper time and place.

3. As a separate, unbiased group, Reliability can make more objective decisions.

4. Environmental tests should be a design tool, not a design obstacle. ■

what is Reliability

. . . continued



MORTALITY CURVE, based on Robert Lusser's concepts, is an idealized basis of reliability that is seldom fulfilled in practice.

Further, such environments as vibration can be tested only in a very limited way, and other environments often require elaborate engineering testing at substantial cost in time, materials and money.

biggest problems are mechanical

Reliability data are relatively scarce on mechanical components; new testing instruments and measuring methods have to be developed. Component suppliers must get a better understanding of reliability.

Some suppliers in the missile field have found it necessary to make special hand assemblies of matched parts to meet R requirements—for hydraulic valves, pumps and many other parts. Many components are known to be overdesigned, thus overweight and too costly, but there just hasn't been time, and tests enough, to solve all the plaguing problems. In one case, an auxiliary turbine, all hand-assembled by the contractor's best mechanics, from parts all hand-checked by engineers, made 10,000 starts without a malfunction. Then five others were assembled with a little less care–and reliability immediately dropped.

Missile difficulties will still go on, because production quantities are so small, the parameters are pushed so far out, and there are endless variations in design and environments. Civilian products, however, are less complex, do not require such high reliability and are made in much larger quantities, so testing is easier and more practical. Also, time is not so important–and human compensation, adjustment and maintenance usually are available.

Common sense can help there, and will be effective if it is supplemented by sound design, careful testing and study of experience records. If science is "the ability to predict," then reliability is a way to accelerate experience so predictions can be made.

SOURCES OF R SCIENCE

The basic definition of reliability was first presented by Robert Lusser, then of the R & D Division, Redstone Arsenal, in a small symposium on reliability at Convair-San Diego in 1952. Several of the concepts were in use in 1950 and 1951, but this was the first get-together on the subject, and Lusser's concept not only introduced the idea of quantitative or statistical reliability, but also established most of the basic principles. He is thus generally regarded as the "father of reliability," although others have developed the idea. Lusser was originally on the V-2 project at Peenemunde, and returned to Germany a bit over a year ago. He is reportedly now chief engineer at Messerschmitt.

His idea of "testing to failure" has proved to be too costly in practice for most products, particularly large and complex ones. It is his belief that there is *no* electronic or electrical failure; that *all* failures are mechanical in nature. This is based on the premise that electronic devices theoretically are not subject to drift failure, but failures result from mechanical causes.

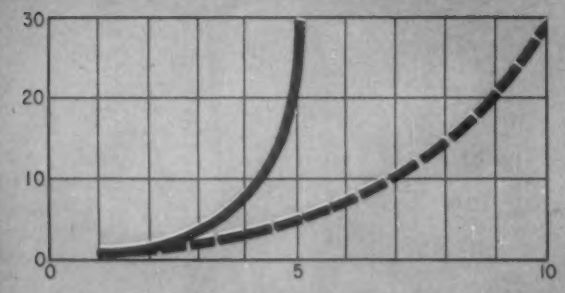
Lusser was also first to make the observation that, given time and tests, a returnable assembly can easily be made reliable. However, a non-returnable assembly like a missile is much more difficult—exact cause of failure in missiles can be traced in only 0.2% of the cases. The Redstone was a reliable missile because reliability was designed and built into it through systematic testing of all components and subassemblies. Therefore, the key to reliability is control established through testing.

While Lusser displayed more energy and force, the late Dr Carhart, originally of Lockheed and later with Rand Corp, showed more intuition in developing the modern concept of reliability. Both the *Sparrow* and *Regulus* missiles, as well as the *Redstone*, were being engineered by reliability concepts as early as 1950 or 1951. But the early programs got off to a bad start, principally because statisticians had a field day with them. Their elaborate prediction techniques proved unsound in practice. The difficulty still is to relate the concept to practical engineering problems, to use experience and other information effectively to obtain a mean time to failure by other than statistical or costly test procedures.

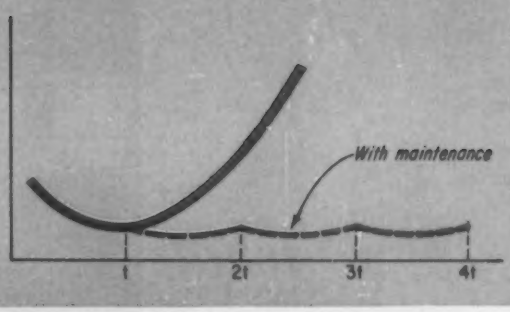
DEFINITIONS OF RELIABILITY

A West Coast engineer's definition, reflecting the uncertainties of the countdown, is: "(1) Did I do it? (2) Can I do it again?" A long-time reliability-group leader adds a sardonic note: "Reliability is the scientific substitute for common sense." Seven reliability engineers, in solemn conclave, amended that to: "Reliability is the scientific *supplement* to common sense."

However, the generally accepted definition, with a word changed here and there on occasion, is: "*Reliability is the probability that a device will perform without failure a specific function under given conditions for a given period of time.*" Note that the mathematical word "probability" is included—indicating relative chance of occurrence. "Failure" means any variation beyond allowable



TYPICAL FAILURE-RATE CURVE FOR A PRODUCT. If desired life (solid line) is five years (30 failures in 60 samples), and actual life is ten years (dotted line) the product is overdesigned. A log scale for failures usually gives a straight-line curve.



PREVENTIVE MAINTENANCE—replacement of short-lived parts at proper intervals—slows the rise of the failure-rate curve. This is true of automobile and aircraft engines, many domestic appliances, machine tools.

limits, not necessarily total failure (which has come to be known as "catastrophic failure" among R men). "Function" is performance requirements—what is expected from the product. "Conditions" are the environmental requirements, such as temperature, vibration, shock, altitude, acoustical noise, and moisture.

The final factor is "time." For the "one-hoss shay" it was 100 years; for a modern turbine maybe only 20 yr; for a missile, 30 min. But the design must be strong enough so it will last its full life at strength adequate to withstand the stress or load. That means it must be stronger initially, because any mechanism gradually deteriorates (what R men call "drift failure").

the jargon of reliability

Every specialty develops its own industrialingo; Reliability has already developed more than most, and adopted some of that of statistics. Here are some of the commoner terms, with definitions:

Oversight—This is a euphemism for a mistake or an error; it spots the reason for failure to meet R standards.

Trade-off—How much of one product quality must be yielded to improve another; i.e. a trade-off between range and reliability of a missile (assuming higher R adds weight, thus reduces range). Particularly beloved by the Air Force, which on occasion requires trade-off charts.

Degradation—Gradual decline in properties or performance of a component or an assembly in service until it drifts outside tolerances or wears out.

Infant mortality—Failures during the first use of a product—"birth defects." Such failures usually result from faulty manufacture, and are weeded out by run-in tests. In consumer products this is called "in-warranty failure"—they have to be replaced; a calculated risk in products designed for planned obsolescence.

Constant-hazard mortality—Accidental failure that is unpredictable, that occurs from the chance drop of solder or the undetected loose chip.

Wear-out failure—Just what you expect: the product that works long and honorably, then wears out. This type of failure is, however, strongly influenced by preventive maintenance, and may be confused with constant-hazard failures of the less-detectable sort.

Failure rate—Percent of products failing in a given time interval, plotted as a function of time. In R work, failure rate is usually designated for a given product or part.

Product proof test—A little test performed to demonstrate that product R is no worse than some preselected value. Requires "no *a priori* (deductive) knowledge about the life behavior of the product." This test usually does not generate information for either product improvement or cost reduction, and should show no failures.

Engineering evaluation test—This time you must have *a priori* knowledge about product life behavior, or you design the test to find it. It will generate information for product improvement and cost reduction, as well as demonstrate R. This test is usually costly because enough units must be tested to determine failure rate. If 25 failures are required statistically to determine the rate, you keep the tests going until 25 failures occur.

Confidence level—How much can you trust your estimates? If the specs say that R shall be 95% for a period of two years, they should include a confidence level for the R. In other words, how sure are you?

Catastrophic failure—complete failure, breakup.

Drift failure—Gradual change of characteristics in service until the unit "drifts" outside permissible tolerances. Seals and bearings often fail this way (see degradation).

Idiotproof—Design to allow for thoughtless, terrorized, or moronic human operation.

Correlation—A relationship between two occurrences, the degree of which may be expressed as a number between minus one and plus one.

Hazard rate—Failure rate at time t, divided by percent of original population still operating.

Mean time to failure—The operating time t of an item of equipment divided by the total number of failures n occurring during the time interval involved.

Random failure—A chance failure that occurs unpredictably—a constant-hazard failure that occurs before wearout and probably should have occurred in initial test.

Inherent reliability—actual product reliability if the product is manufactured according to design.

Reliability index—A numerical constant that describes the probability of random failure and usually is not related to the implied meaning of an item's "life."

Ignorance factor—Lack of knowledge of the characteristics of a component or subassembly. This must be reduced if R is to go up. ■

what has been done

SIX AIR-DATA COMPUTING SYSTEMS were used by AiResearch in a recent reliability test which showed 1500-hr mean time between failure. These three of the systems accumulated 1000 hr of failure-free operation. Each unit went through a programed series of problems every 4 hr. During a quarter of the test cycle, units were subjected to double amplitude vibration of 0.018 in. at 5 to 35 cps.

The most important step toward the achievement of reliability is to recognize it as a design problem. We have had advertising copy on "quality," "rugged design," and a host of other terms, as well as "reliability," but none supported by solid statistical evidence; none included the concept of *time*. Critical military needs forced a new approach, which works soundly in industrial products as well.

1. Reliability has been made the specific responsibility of specific skilled people with authority to correct unreliable conditions or designs. They are a service department for designers, historians who arrive at conclusions, make suggestions, catch "oversights."

2. The nature and causes of failure have been explored. We now know **why** and **what** as well as **when.**

3. R thinking has been applied even to the smallest components, and many have been vastly improved. **There is no unimportant part.**

4. Statistical methods have been used extensively to gather data and apply them in increasing equipment reliability.

5. National conferences on the subject have spread the knowledge, and provided techniques and examples.

6. Reliability design objectives are now set forth in many military contracts—recognizing that reliability cannot be "tested into" a product; it must be designed in.

7. Many products have been analyzed for inherent reliability (and many have been changed to improve it). Simplification of design and reduced numbers of parts result.

8. Tests of incoming materials and components have been re-oriented to weed out faulty ones *before* use.

9. Quality control and tests have been redirected and made more stringent and thorough.

10. Manufacturing methods have been tightened, not just to reduce scrap percentages, but to guarantee quality parts in assemblies. "Oversights" are caught. Many tolerances have been tightened, some loosened; the objective is shifted to avoid putting added labor and time into a faulty job.

11. The systems approach to reliability has brought the realization that design, manufacture and use must all be considered; has shown the importance of redundancy, proved the value of preventive maintenance, and reduced over-design.

12. The relationship of quality to time (both in storage and in use), of mistreatment in delivery to malfunctioning in service, of empirical design to analytical design, are much better understood. ■

failure rates for typical components

MECHANICAL	FAILURES/ MILLION HR
Clutch	100
Reservoirs	5
Disconnects	27
Bellows	5
Solder joints	1
Thermostats	6
Relays	10
Accelerometer	189
Brake, axial (motor)	20
Clutch, axial friction	15
Clutch, hysteresis	10
Counter, mechanical	3
Differential	15
Engines, jet	4000
Gyro, floated, inertial	190
Gyro, nonfloated	105
Motor	15
Servo motor, generator, integ.	360
" " " position	18
HYDRAULIC	
Actuator seal, slow leak	5000
Actuator seal, system drained	50
Actuator, all other	200
Pump, shaft seal, slow leak	500
" " " system drained	67
Pump or hyd-motor bearings	333
Pump case, drainage	33
Pump shaft, loss	500
Pump, all other	500
Filters, checkvalves	2
Fittings, cracked, etc. slow leak	5
Fittings, blown, cracked, drains system	1
Lines, cracked or ruptured	1
Mechanical linkage	1
Relief valve	1
Shutoff valve, will not shut off	1
Shutoff valve will not turn on	200
Flow regulator, plugging	1
" " loss of regulation	Less than 1
Control valve (tandem)	50

how to design for Reliability

To design for reliability, you have to keep in mind that the equipment must withstand **actual,** not **expected,** service conditions **for a given length of time.** This immediately introduces prediction and probability, with a scatter pattern of failure. Three considerations in design are each affected in turn—environment, analysis of loads, and behavior of materials. Time is the independent variable; loads vary with time, material behavior is influenced by it, stress analysis must consider strain rate.

You must recognize seven types of failure, with two or more occurring at once:

1. **Static.** Fracture occurs during a single application of load. For ductile materials, stress analysis will determine whether stresses are below the yield point. For brittle materials, determine max principal tensile stress.

2. **Brittle.** Occurs under static load conditions, without evidence of plastic flow. In ductile material, when defects are present in highly stressed zones. Energy-absorbing capacity is a function of temperature. Watch for a transition temperature within operating-temperature range.

3. **Instability.** Oil-canning of plates, popping of shells, and buckling of columns. Governing factor here is strain energy stored in the member. If a small change in work done by external forces is greater than the strain energy, the system is unstable.

4. **Creep.** Deformations increase with time. Relationship between temperature, stress, strain, and strain rate is empirical and determined by tests.

5. **Corrosion.** From chemical action of the atmosphere, dependent on time; strain may increase corrosion rate, particularly under cyclic stress. Results cannot be predicted; tests are essential.

6. **Fatigue.** Cyclic loads propagate a crack that starts in a small defect, surface scratch or corner. Damage accumulates until fracture is produced. Most service failures are caused by fatigue.

7. **Sticking.** This can be a serious source of difficulty in mechanical assemblies.

Each type of failure requires a different point of view, different analysis and different test procedure. If incipient failure can be detected by routine inspection, a smaller safety margin can be tolerated. Creep and corrosion are visible before failure, brittle fracture or fatigue are not.

In addition, manufacturing tolerances can introduce stresses that are not calculated in the idealized structure. If two parts rub, fretting fatigue will occur, which can cut part strength 50% or more. Improper grinding may embrittle a surface; hammering a part to straighten it may set up residual stresses; also defects in casting or welding, poor surface finishes, overtight or faulty bolting or riveting. If inspection is likely to be difficult or impossible, the safety margin must be larger also.

approaches to the problem

A given design problem can be approached either on a fail-safe (one known weak spot) or one-hoss-shay (all parts equally strong) basis. Fail-safe design depends on the weak spot to act as an electrical fuse when the dangerous environment occurs; the fuse "blows," and can be replaced. Another fail-safe method is redundancy—addition of a duplicate element to share the load or accept it.

If weight or cost must be minimum, the one-hoss-shay approach may be used, with ideal strength in all parts. Practically, it is difficult, because parts fail in different ways and at differing rates—some by creep, some by fatigue, some under static loads. Some are dependent on time, others are not.

THREE STEPS TO RELIABLE DESIGN

since reliability is 99% experience:

1.. Study similar predecessors to learn what you can.

2.. Focus on variations in the new design.

3.. Specify conservatively to start—rate up as experience shows you can.

environments and their effects

Most parts will operate under a series of environments:

1. Before-assembly individual environments
2. Internal environment generated by the product
3. Shipping and storage environment
4. Operational environment of the product

Generally speaking, the first three are preoperational environments, including stresses imposed on the parts during manufacture, assembly, inspection, test, shipping and installation. Of these, the worst may be shipping, involving shock, humidity and drastic temperature changes far beyond those to be encountered in normal operation. This is especially true for domestic appliances.

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how to design for **R** *eliability*

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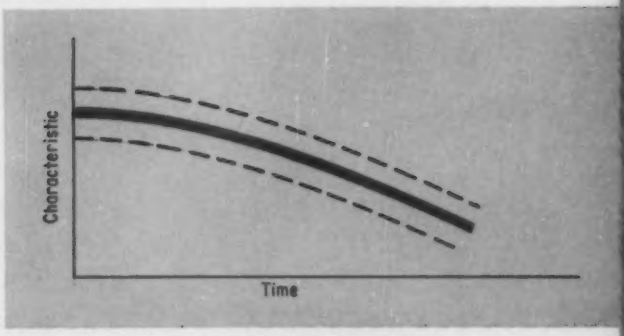


STRENGTH OF A MECHANICAL PART, or any other characteristic, may drift off with time—with the average or median value following this type of curve. Individual variations within "uncertainty limits" establish the functional tolerances.

HOW TO INSURE RELIABILITY IN DESIGN

The reliability concept adds to the designer's job the responsibility of proper manufacture and use, because the **design** can meet all requirements, but the **product** may not. To avoid this contingency, the designer must **completely specify** how the product will be made. He must:

1. Specify all tolerances and tests. These must weed out defective components and assemblies at the earliest possible stage.

2. Specify materials by characteristics for the particular job. Vendor's tradenames or designations must be supplemented by tolerances on important characteristics. The vendor may change process or some basic characteristic without a name change.

3. Specify manufacturing procedures when required. This may be the only way to control life-behavior characteristics of a component.

4. Specify sources of supply. Purchasing cannot be relied upon to detect changes described in the two preceding paragraphs. If vendors are changed, the components or materials they supply must be requalified.

5. Specify installation, maintenance and use procedures to control these phases of product life, because all three have major effects on reliability. The R group, if one exists, can advise and suggest, check and test, but the responsibility for inherent reliability is the designer's.

6. Simplify equipment and components. Reduce number of parts, cut adjustable elements to a minimum, restrict adjustments to within the necessary range, simplify inspection and checking procedures.

7. Select reliable components. Given the choice, select the more reliable material, component or system.

8. Provide for replacement. If a part with a high failure rate must be used, provide for its rapid and easy replacement. This does not improve R directly, but it may help by preventing damage to other parts during replacement.

9. Know when to derate and when to use redundancy.

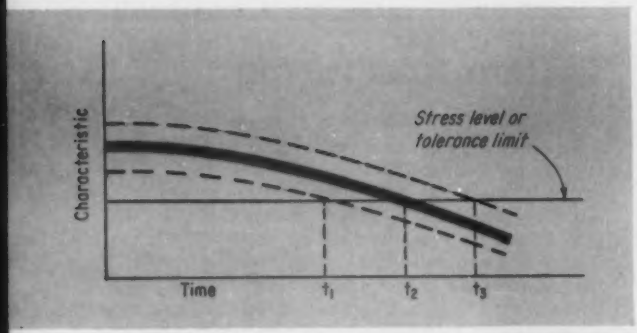
The operational environments, on the other hand, are those for which the product might be expected to be designed. They may be quite critical, especially if they include adjacent heat or vibration generators or other mechanical or electrical conditions that may be detrimental. Here, too, must be considered the necessity for, and the likelihood of, service and maintenance. Service is periodic cleaning, greasing, oiling; maintenance is the scheduled replacement of short-lived components to extend the over-all service life—called preventive maintenance in industry. Indeed, some products (like jet engines) would have no "constant-failure" portion of the failure curve if this were not done.

Environments which affect reliability include: shock; vibration; humidity; radiation; ambient temperature; surrounding-surface temperature; finish and configuration; available coolants, their temperature, flow rate and other characteristics; sand and dust; fungus, acoustical noise; electrical noise; corrosive liquids or gases (if present); electrical fields; magnetic fields. About each, you must know magnitude, duration, rate of change, and interdependence on one another. These time characteristics of environments will control design, not some average value or assumed maximum value.

why components and materials fail

Products may fail for any of three reasons: improper design, improper manufacture, improper use (environment). Our major concern is with the first one. We must design for a specified, or a long, life, and this requires a knowledge of the life behavior of all components and materials. The product may fail through drift—gradual change of characteristics or decline of properties (degradation)—until it is outside permissible tolerances. A bearing, a seal or a finish (through corrosion) may fail this way. The other kind of failure is called **catastrophic**—complete failure—as the burnout of an electrical component or breakage of a shaft.

In no case, of course, do all components or materials of a type fail at the same time, nor do they follow the average pattern. As shown in accompanying sketches, there are uncertainty limits or tolerances. In the ideal situation, these are measurable and can be charted. But in other cases, the component cannot be tested for a particu-



FOR A GIVEN PERFORMANCE LEVEL, here is the way uncertainty limits for a component affect product life. The first drift failures will begin at time t_1, half the lot will fail by t_2, and all of lot by t_3.

lar characteristic without being destroyed. Here the uncertainly limits are not measurable directly; they result from the manufacturing process. In such cases, the uncertainty limits are established mathematically.

The slope of a characteristic-vs-time curve is determined by the manufacturing process, hence is not directly measurable, and can be used to predict product life only if every unit is made by the identical process. Any change, even if apparently trivial, may seriously affect the curve. Thus it may be necessary to establish variations from batch to batch if parts are made in batches, or to redetermine the characteristics if the process is slightly changed.

some added points

It goes almost without saying that to design reliable equipment, the designer not only must be competent in his own specialty, but also must be familiar with any other technology involved—or have specialist assistance. He must be able to equate maximum design against such other characteristics as maintenance. In a missile or a transoceanic cable, the finest materials and components must be used, because cost of maintenance and effect of early failure far outweigh any difference in first cost. But in an automobile or a motor, maintenance is relatively easy, so lower-priced elements may be designed in, the object being to cut first cost. In the automobile, for example, service life can be doubled only at a cost increase of five or six times, even though the automobile is about the only consumer product that receives regular preventive maintenance.

Standardization is another technique that increases reliability. It makes use of readily available, proved-reliability components and materials, with much R experience available and sound manufacturing, QC and installation techniques. Spares are readily available. However, the available standard elements must be suitable for the **particular set of conditions.**

Still another technique is "building-block" design, combining standard assemblies in various ways. This provides the virtues of standardization from a reliability point of view, while permitting specialized designs of the final assembly. Much R data can be accumulated on the building blocks, and readily transferred.

DESIGN FOR ENVIRONMENT

Loads, temperature and atmosphere are the three most common environments, with time as an independent variable. Loads can be external, or dynamic forces from component inertia, or induced by thermal expansion. They may be measured or calculated; you'll feel fairly safe if one method has been used to check the other; if not, you'll want to know which was used.

Maximum loads alone tell little; what is the rate of loading and the complete load-time curve? A load spectrum gives relative frequency of load amplitude, but not rate of load application or vibration frequency. This is done better by a continuous load-time curve. You cannot know precisely the number or extent of all loads but you can set up a probability of occurrence.

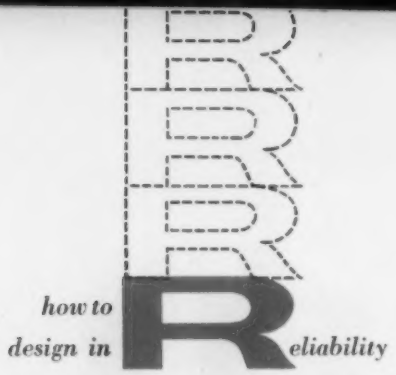
Temperature causes expansion or contraction, which may in turn set up stresses. Also, properties of the material vary with temperature. Service records must be augmented by test and calculation to provide data. Temperature is likely to be less uncertain than load, so a spectrum usually is not necessary.

Corrosion weakens parts progressively, but there are no

THE CASE OF THE CLEANING SOLUTION

■ A small connecting-rod which must operate at a fairly high stress level is incorporated in one product made in large quantities. The vendor had been producing excellent parts, but suddenly the purchaser's proof-testing program began to show a large number of early failures. Investigation showed no change in material, forging, machining or heat treating. The only change proved to be substitution of a new cleaning solution. The new cleaner contained a weak acid which caused hydrogen embrittlement of the rod. Cost to the company, based on laboratory life tests, of in-warranty failures from this one cause: $300,000.

Moral: (1) There never is an "insignificant" change in design or procedure. (2) Never stop proof-testing parts, no matter what the R has been. In this case, proof-testing showed the condition before user failures began to occur. Costs would have been much greater had proof-testing been abandoned to "cut costs." ■



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fixed rates. Usually the best method is to conduct tests under simulated service conditions.

Basically, reliability is affected by how closely your estimates of environments compare with actual service conditions. It is usually preferable to assume a certain set of service conditions with a probability rather than to design for the worst possible conditions.

stress analysis

Some common methods of stress analysis, and their effects on reliability, are:

1. Elastic. Based on the assumptions that materials are homogeneous, isotropic and obey Hooke's law. With a few notable exceptions, most of them do follow these assumptions. But there are variations arising because formulas are based on idealized geometries and boundary conditions. Safe tolerances can usually be established for these errors, and reliability is not usually affected because the variations are too small.

2. Plastic. Creep, cold-forming, low-cycle and static fatigues are among potential failure conditions which can be investigated only by means of plasticity theory. This is complex, so isn't as well developed as elastic theory. (See "Reserve Strength in Metal Parts," *PE—Sep* 29 '58, p 44, and *Dec* 21 '59, p 45.) The method is approximate, and prediction of safety margins can be determined only from behavior of the material.

3. Strain measurements. Elastic-resistance strain gages will accurately measure strain at the attachment point, can check analyses or will determine strain if geometries or loads are too complex for analysis. Limitations of gages are that they measure strain over a finite length only, that average rather than maximum strain will be measured if gradients are large, and that only surface strains can be measured. Within these limitations, results are quite accurate.

Photostress methods (*PE—Mar* 2 '59, *p* 43; *June* 22 '59, *p* 89) permit evaluation of surface stresses over irregular, uneven and small areas, and can also give instantaneous visual indication. Accuracy is comparable to strain gage.

Stress coat preserves a visual record of the maximum surface strain attained over flat or irregular surfaces. Calibration is by visual comparison with a standard sample.

Photoelastic models provide precise and easily obtainable data for computation of principal stresses in plane sections; for three-dimensional parts, well-developed stress-freezing techniques are available (*PE—July* '57, *p* 135).

What you need is the relationship between stress condition previously produced by the environment and a

RELIABILITY DESIGN CHECKLIST

A. Product Requirements

1. Are all functional, reliability and other requirements specified?
2. What are the environment requirements? Are they reasonable, based on experience? Are they based on measurement or conjecture?
3. What are reliability requirements? Are they too severe or too lenient? Consistent?

B. Preliminary Design

1. What proved design can meet functional requirements?
2. What standard components and assemblies?
3. Does this environment differ enough to affect the above?
4. How much environmental extrapolation is necessary?
5. Is expert advice available?

C. Design Analysis

1. How does each component and material behave under these environments?
2. How dependable are available life data?
3. Can reliability be calculated from available data? Do gaps exist, and if so, can they be filled?
4. Can complete units be built for test?
5. What are the weakest links in the design?
6. Is R high enough, or is redesign indicated?

D. Corrective Action

1. Will expert technical assistance help?
2. Can Manufacturing or QC give advice?
3. Is the R limit set by one or two components? If so, can they be redesigned or derated? Or is redundancy the answer?
4. Can environment be changed—heating, cooling, shock mounting, shielding?
5. Is redesign indicated?

(Steps C and D may be repeated several times)

E. Final Design

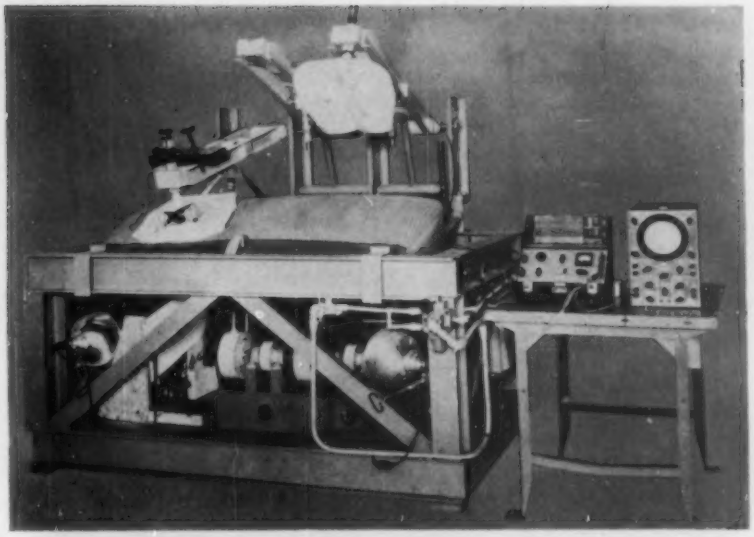
1. Can production, inspection, purchasing help in writing specifications?
2. Can specs be written to assure 100% test and inspection?
3. If component characteristics cannot be 100% tested, are there suitable manufacturing and QC procedures?
4. Which component will be subcontracted or purchased? Is there a list of approved vendors?
5. Can procedures for inspection and test be inserted to reject defective parts early in manufacturing?
6. What minimum number of tests and inspections must be made at each stage? Must all characteristics be tested?
7. Will a "shakedown" test eliminate substandard units more easily?
8. How much testing can be done safely without cutting product life appreciably?

F. Redesign After Pilot Run

Must be carried back to Step C.

THE CASE OF HERS AND HIS

■ Designed to life-test auto seat cushions for fatigue, this machine at Battelle is powered by a variable-speed hydraulic motor having a testing-speed range of 30 to 200 cpm, making these standard buttocks pound somewhat faster than their real-life counterparts do, even on the roughest road. In addition to fatigue testing, this setup studies damping, load distribution, and permanent set of seat cushions. ■



quantity that can be measured easily in the laboratory, using the methods listed above. This is seldom possible. For example, you cannot predict fatigue limit from ultimate or yield strength; substituting a material with higher ultimate strength won't necessarily raise the fatigue limit proportionally.

value of simulated tests

The less you know about material behavior under the specific operating conditions expected, the more nearly the test must simulate the environment to get reliable performance in use. Three types of tests are possible, in decreasing order of cost and complexity: simulated service, component, and laboratory.

1. Simulated service. This is an elaborate test, and if properly done, has high reliability. But extrapolation can lead to inaccuracy, especially in testing long-life equipment. Results are also likely to show scatter, and many tests must be run to obtain a high confidence level.

2. Component. Object here is to determine intereffect of geometry and temperature or some other environment under relatively simple loading. Environment is usually not completely simulated. These tests evaluate or establish design procedures, but cannot establish a high probability of survival. If extrapolation of results is a problem, component tests will give a more reliable estimate of the probability of survival than simulated-service tests for the same cost and time.

3. Laboratory. Relatively inexpensive tests of standard specimens, usually under simple loading, establish a base line for material behavior—probably the upper limit on strength to be expected in service. Must be supplemented by consideration of such effects as stress raisers, surface finish and residual stresses, plus service conditions differing from those of the tests. These decisions largely determine product reliability, and suggest why these common tests so often differ from service results.

DESIGNING FOR FATIGUE

Most service failures result from fatigue, so translating laboratory test results into a design with high reliability is difficult. For example, in the lab, the usual load is of constant amplitude, varying sinusoidally. In service, loading varies constantly both in amplitude and in frequency. To correlate the two the concept of cumulative damage must be applied.

Cumulative damage. In the typical S-N curve from lab tests on a metal (see diagram at top of next page), the ratio n_1/N_1 is a measure of damage if only n_1 cycles, rather than the N_1 required for failure, were applied. This is called the cycle ratio at stress S_1, and is the variable used in assessing the strength of a part subjected to a number of different stress amplitudes. According to Miner's hypothesis (*Metal Fatigue*, Ch 12, McGraw-Hill, 1959), if stress amplitudes of S_1, S_2 and S_3 are expected in service, the

continued, next page

THE CASE OF THE LOBE SWITCH

■ Electromechanical analog position computers for use with Doppler radar sets made at General Precision Inc are 50% mechanical (gears, shafts, bearings, etc.—excluding nuts, bolts and brackets), but mechanical failures were only 2% of the total—except for a lobe switch, part of the antenna. This is a single-pole, double-throw microwave energy type. Energy enters the switch through the leg of a waveguide T. The position of a vane in the center of the T determines which arm of the T will be the output. A solenoid motor swings the vane back and forth through 90° angle at 1 cps.

Mechanical stops deformed under impact, bearings failed, parts became loose, shafts broke in fatigue, and insulation softened at operating temperature. One by one, the weaknesses were found and corrected—increasing the life from a few hours on the first units to well over 500 hours, the normal operating life needed for the application. ■

how to design on Reliability

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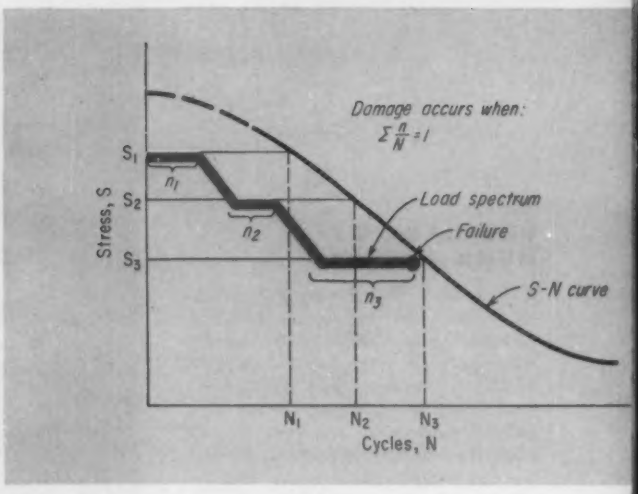


CUMULATIVE DAMAGE THEORY says that varying stress cycles can be added to predict failure, but tests show that failure often occurs before the theoretical prediction.

corresponding cycle ratios n_1/N_1, n_2/N_2, n_3/N_3 would add up to unity.

Experiments show that the sum varies, however, from about 0.6 to 1.5. The smaller values are obtained when the larger stress amplitudes are applied first; the larger when the reverse is true. Because the order of load application in service is usually unknown, the minimum value of 0.6 is used for the sum of the cycle ratios. This value must, however, be adjusted by tests on the particular material if reliability is to be attained.

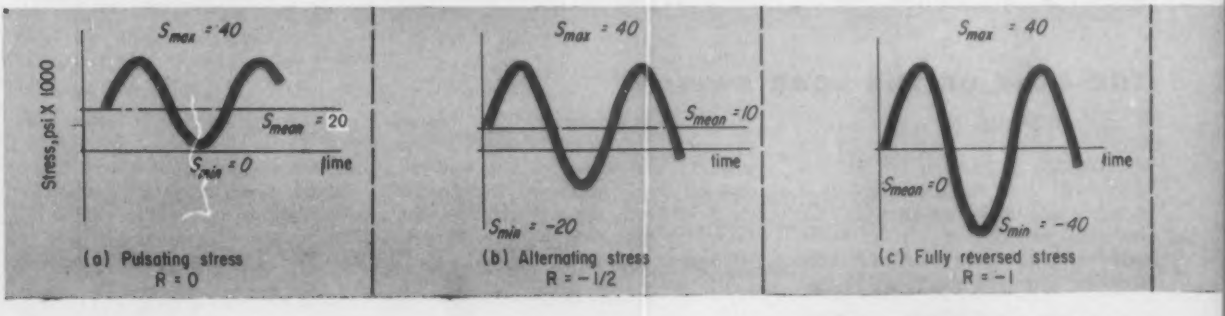
Stress cycle. Service loads are usually not completely reversed; i.e. stress does not vary between equal values in tension and compression. The stress cycle is usually defined by two values: a maximum stress S_{max} and a stress ratio R, the ratio of S_{min}/S_{max}. These two figures allow the stress cycle to be sketched as a variation around a mean stress, as in the diagrams below for three sinusoidal cases —each with identical values of S_{max}. Fatigue life varies with load pattern as shown in the "stress-range" diagram, which plots results of fatigue tests run at many different combinations of R and S_{max}. Such "stress-range" diagrams are plotted in terms of reversed stress and mean stress, however, with cycles to failure N as the parameter. Each load pattern represents a point on the mean stress curve. Note that even though S_{max} is the same for all three, fatigue life for each is different—N_c could be as low as 1/1,000 of N_a. Thus thorough knowledge of stress cycle is essential for reliable fatigue performance of the part.

Biaxiality. Most fatigue failures occur at the surface of a part, where stresses are usually biaxial. But fatigue testing most commonly employs uniaxial conditions, thus fatigue strength is essentially a uniaxial quantity. To relate biaxial service stresses with uniaxial test stresses, a theory of metal failure is used. The most widely used is the "distortion-energy" theory, which states that elastic failure occurs at a point when the energy of distortion at that point, as computed from principal stresses, exceeds the energy stored in a simple tension bar of the same material subjected to a uniaxial stress. Termed the "effective stress," it can be a percentage of yield strength or, in the case of fatigue, a certain percentage of the fatigue strength. In terms of principal stresses S_1 and S_2, and fatigue strength S_f, this relation is

$$S_1^2 + S_2^2 - S_1S_2 = S_e^2 = (kS_f)^2$$

When S_f is taken as the uniaxial fatigue strength, and the member is sized through the above equation, an error of 10 to 20% can be expected. For greater precision and thus greater reliability, the material should be subjected to biaxial fatigue tests.

Metallurgical changes. Shifts in metal structure, particularly in response to high service temperatures, can affect fatigue reliability. Examples are: recrystallization, phase changes, and precipitations. Laboratory tests that approach service life in length will reveal most of these effects, though service conditions not present in tests may



produce additional metallurgical change. More sophisticated testing or expert advice will help in such cases.

Scatter. Data spread is especially pronounced in fatigue testing; it may readily be two logarithmic decades in part life and 20% in strength. However, scatter in service life may be even greater because variables such as surface finish and stress raisers are not so carefully controlled.

The rational method of handling this is to introduce probability into the S-N curve to arrive at an appropriate design stress (see P-S-N diagram). Usually, test results are insufficient for this plot, so some relation for the stress for a certain N and the probability P of failure must be assumed. As long as probability is not very low or very high, normal distribution fits the data reasonably well; tables are readily available. Other distributions have been used, but even an assumed distribution and a design stress selected for some probability of survival are still preferable to an arbitrary safety factor.

Extrapolation. If the part is to have a very long life, lab test results for a shorter period have doubtful value—unless the material has a definite and known fatigue limit. Then tests values can be extrapolated, if allowances are made for time-dependent effects like corrosion. Normally, however, only long-time tests will assure long-time reliability in selection of design stress.

fatigue design—an example

PROBLEM: To design a member subjected to axial load of varying amplitude for 5-year life, with a probability of failure of 0.1%. (Contributed by R. P. Felgar, General Electric Co.)

Load sequence from service records of a similar part is converted to a load spectrum by counting the number of cycles at various load amplitudes for a year. P-S-N curves for the light-alloy material are known; thus environment and behavior are available. Stress analysis is simple, stress

THE CASE OF THE HARD SPOTS

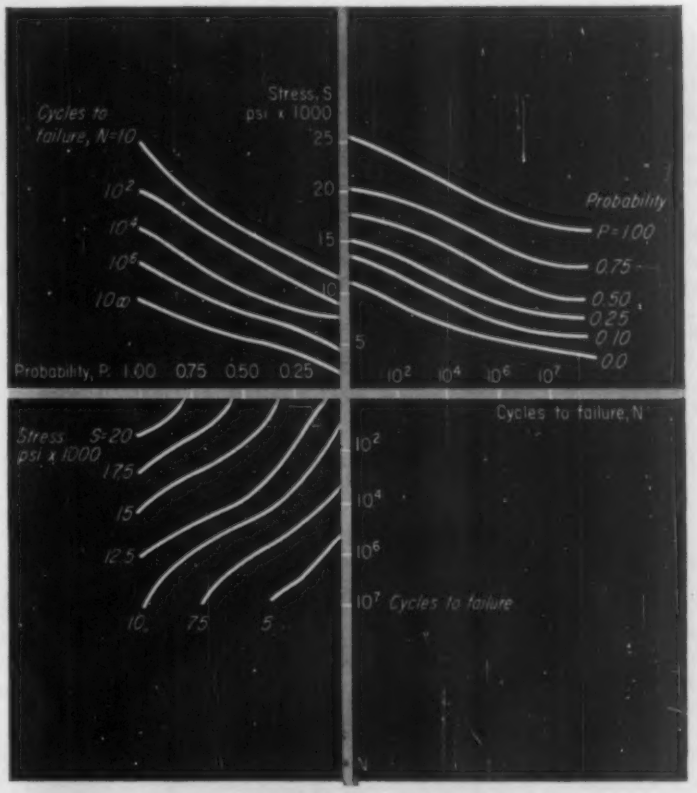
■ Farmer drilling machines produce high-precision holes with high length-diameter ratios. Of necessity, drills are long and thin, subject to bending or drifting, especially when they encounter a hard spot. Typical application: drilling oil holes from crank end to wrist-pin end of connecting rods.

A number of Jaguar connecting rods were drilled too close to one side and broke under test or in operation, requiring extensive rework or field service.

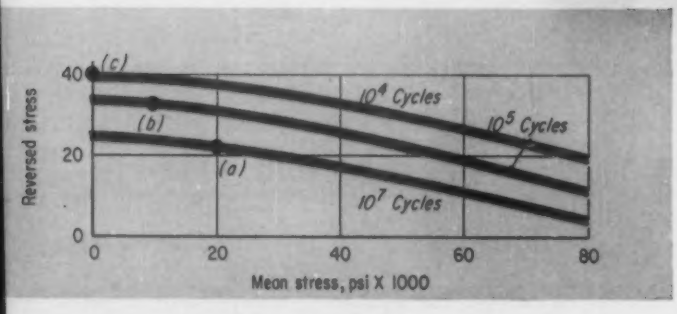
To prevent drilling of a crooked hole, a sensing device now continuously measures power demand on the drill-spindle motor. Even slight bending adds frictional and bending forces to those needed to drill the hole. When demand exceeds a preset limit, the spindle retracts and advances a number of times until the drilled hole is again straight and the hard spot is drilled through.

Even under normal conditions, the retract-advance sequence is now programed into the operation to clear the hole of chips.

Moral: Adjusting to a stress may improve reliability. ■



P-S-N DIAGRAM allows for scatter in endurance life by introducing probability into the S-N curve.



STRESS-RANGE DIAGRAM shows that fatigue life varies with the extent of stress reversal even when the maximum stress is unchanged.

how to design in **R** *eliability*

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being load divided by area. Employing this computation procedure in the table:

Tabulate load amplitudes and frequency, *columns 1* and 2, Table I. Cross-section is 0.5 sq in.; dividing load amplitudes by this area gives the stress values in *column 3*. Cycles to failure, *N*, for each value of stress are obtained from P-S-N curves for P = 0.1%, *column 4*. Finally, cycle ratios are computed in *column 5*. Their sum is 1.13—greater than the allowable value of 0.6. All load cycles must be multiplied by 0.6/1.13 = 0.53 to make the sum of cycle ratios equal to 0.6. This means that the life for 0.5 in.^{2} cross-section is only 0.53 years.

Evidently, predominant stress must be reduced for life to be increased to five years. In *column 5*, the largest cycle ratio is for a stress of 28,000 psi, at a life of 1.1×10^4 cycles, corresponding to a part life of 0.53 yr. So $(5/0.53) \times 1.1. \times 10^4 = 1 \times 10^5$ cycles for 5-yr life. Stress for this life, P-S-N curve, is 22,000 psi. The new approximation: $A = 0.5 \times 28/22 = 0.64$ sq in. The second set of cycle ratios, for A = 0.64, gives the summation of $n/N = 0.157$. Life of the components is 0.6/0.157 = 3.8 years.

A third trial value of A = 0.69 sq in. gives life of 5.4 yr. This is close enough.

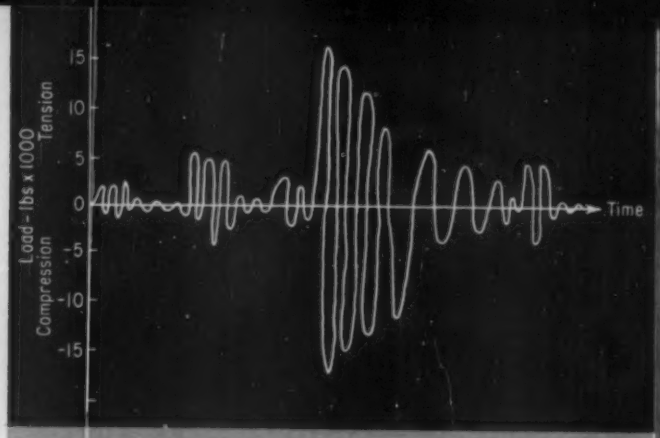
EFFICIENCY IN FATIGUE TESTING

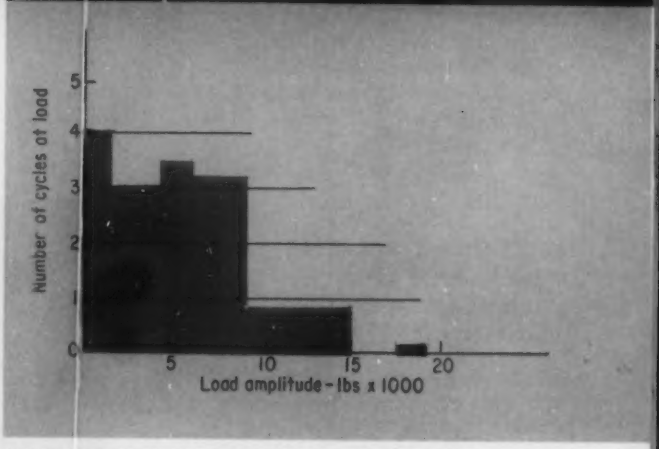
Probability data needed in designing for fatigue require a great many long-term tests. They must be done by efficient methods. Here are three:

Prot Method—Specimens are subjected to stress cycles increasing in amplitudes at a set rate. Stress at failure is plotted against some fractional power (usually half) of the stress rate. It is then assumed that extrapolation to zero stress rate will determine the fatigue strength.

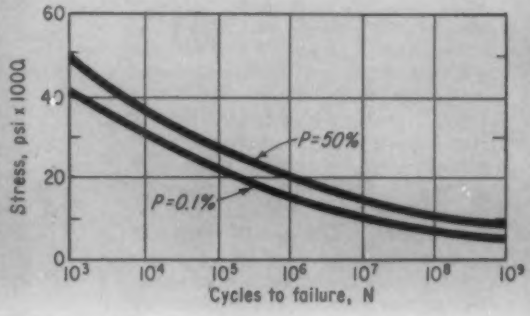
Staircase—A go- or no-go procedure preferred over Prot for engineering metals. Mean fatigue strength and standard deviation for a prescribed number of cycles are estimated. The first specimen is tested at the estimated mean fatigue strength. If it survives, the second specimen is tested at a stress one standard deviation higher; if it fails, the second specimen is tested one deviation lower. Tests proceed until the required number of specimens are tested. Formulas for computing mean and standard deviation are available.

Least-of-Four—Four specimens are tested simultaneously in four identical testers. Tests are stopped when the first specimen fails. Number of cycles at failure is a statistic giving probability that the population will survive that number of cycles. ■





LOAD SEQUENCE from service records (at top) translated to a load spectrum (above).



P-S-N DIAGRAM FOR THE LIGHT ALLOY.

TABLE I—COMPUTATION PROCEDURE

1 Load, lb × 1000	2 Cycles ($n \times 10^4$)	3 Stress, psi × 1000 $A = 0.5$ in.^{2}	4 Life, N	5 Cycle Ratio, n/N
1	4.0	2	10^9	Negligible
3	3.2	6	3×10^8	"
5	3.6	10	1.3×10^7	"
8	3.4	16	1.2×10^6	0.003
10	1.0	20	2.0×10^5	0.05
12	1.0	24	4.6×10^4	0.22
14	0.6	28	1.1×10^4	0.55
16	0.0	32	4×10^3	0
19	0.05	38	1.6×10^3	0.31
				$n/N = 1.13$

how to raise Reliability

Let's assume the product has been designed properly, with standard parts and sound assembly. But R calculations or tests show the product is not up to requirements. What can be done? Complete redesign is one alternative, but improvement of the weak links (or parts) is usually the cheaper one, and there are three ways to do it: (1) derating the part, (2) redundancy and (3) protection.

Derating is based on the usual proposition that working life of both mechanical and electrical parts can be extended if load is reduced. For example—on a battery, a cantilever or a gear train—make the part or system heavier for its job.

Redundancy is merely a different name for standby, backup or parallel systems or components—an added stage of amplification, or another lever. Standby systems have been used for years: a second boilerfeed pump, an auxiliary diesel-electric generator, batteries for emergency lighting, alternate machine tools in an automated line. All these take over when the original system fails, being switched in either automatically or manually. Duplicated elements have been used frequently in electrical and electronic design, i.e.: in computers, aircraft and missiles. In electrical setups, there may be series redundancy instead of *parallel*—duplicated elements in series to guarantee "fail-safe" operation.

Robert Lusser warned against redundancy in missiles because "no human being is aboard to make the decision to switch over," but it may be the only practical way to raise reliability with available components. The penalty is, of course, increased weight, cost and complexity, plus weight and reliability of the switching device or method.

In practice, the reliability of a redundant system is usually severely affected by the reliability of the switching device or selection system. Unless this system has a high reliability, it may nullify the expected gains for redundancy in a missile. In other than missile systems, however, delay in switching, added weight and complexity may be relatively unimportant beside the necessity for maintaining service.

Some R men delineate two types of redundancy, full-time and standby. Previous discussion has been limited largely to the latter—a component or system which replaces another only when the first one fails. This one, particularly suitable when the primary cause of failure is wear-out, requires a highly reliable sensing and switching device.

In full-time redundancy, all redundant components or systems operate at the same time. This is particularly useful when chance failures may be expected. Examples: a multipole relay with all contacts wired in parallel, a 4-engine plane capable of takeoff on three or flight on two.

Protection, the third alternative, means insulation of the component or system from the environmental stresses which significantly reduce its service life. Type of protection employed depends on whether the detrimental stresses are transient or steady. Thus, steady mechanical stress might require addition of a vibration mount, while transient stress might require both vibration and shock mounts. Steady thermal stress might require insulation or shielding, plus heating or cooling, while transient stress could skip the latter or substitute a thermal capacitor (heat or cold sink). Steady electrical stress might require insulation, shielding or filters, while transient-stress protection could be provided by fuses or circuit breakers.

Whether or not protection is the answer depends on the product; protective devices may be too bulky or too heavy, even too costly. Usually, however, it is easier or cheaper to protect components than to develop new components that will tolerate the adverse environments.

testing the "Reliability Critical" part

In the search for a critical weakness in the assembly, testing is directed primarily at the "reliability critical" components that cause catastrophic failure. First, according to Convair; sort out the assemblies subjected to the most severe environments, those most likely to cause injury to people or damage to adjacent devices, those used in quantity and likely to be used in quantity in future designs. Then, review with these "ground rules" in mind:

1. Test at least five components, ten as a maximum, depending on the compromise between statistical confidence in test results and economic considerations. A single test of a component proves nothing. Convair selects a sample size equal to the product of the standard sample size times the square root of the number used in a product.

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MATHEMATICS OF REDUNDANCY

Assume two systems in parallel, A and B, either capable of completing the mission alone. Call reliability R and probability of failure F. Then:

$$F_A = 1 - R_A, \text{ and } F_B = 1 - R_B$$

The probability that both systems will fail is $F_A \times F_B$ according to the rule for independent events, and the probability that both will not fail is $1 - F_A \times F_B$. Therefore reliability is:

$$R_{A \text{ or } B} = 1 - F_A \times F_B = 1 - (1 - R_A)(1 - R_B).$$

If R for A is 80% and for B is 70%, R for the redundant setup is $1 - 0.20 \times 0.30 = 94\%$.

2. **Test supplied components yourself;** don't accept supplier's test results as final.

3. **Select components from suppliers on a random basis** from production deliveries, without previous notice to the supplier.

4. **If several suppliers are involved,** a minimum standard sample from each supplier is tested, even though all components are bought to the same specification.

5. **Test dynamically,** with components functioning as they do in service.

6. **Test components in largest possible assemblies,** to assure that as many variables as possible are included.

7. **Test under combined environments whenever possible,** but if not possible, test under single environmental conditions in turn. The combined environments of actual operation always reveal weaknesses no single test does. If a choice must be made, combine the three most severe environments; if single environments must be used, start with the least severe.

8. **Test first at design level,** than at 10% or greater up, then at three times this overload. This increases engineering confidence in performance margin, and provides test data if conditions become more severe than anticipated.

9. **If a component fails in test,** repair it as often as feasible to complete the test program, with failure diagnosis if repair is unfeasible. Each failure is a weakness and needs diagnosis and prompt corrective action.

10. **Hold accumulated total test time to a minimum**—to minimize effects of total test time on components.

11. **Improvements or alterations are not made on components during testing**—they invalidate results and distort interpretation of test data.

12. **Tested components shall not be used in finished products.** ■

the human factor in Reliability

Man is an excellent servo device, but will fail on occasion, will be careless or inattentive. He must be protected against himself. In large aircraft, for example, designers are now considering the use of computers to provide data for takeoff faster than the flight engineer can do it, then switching the computer to continuous flight-checking of various elements. This reduces dependence on the human element, gives longer warning for countermeasures and reduces preventive maintenance.

Required performance in missiles crowds the state of the art. Designers face novel demands with limited data. Performance places severe limits on reaction and response time. Complicated interactions of large totals of men, mechanisms and facilities must be integrated tightly on an unprecedented scale. Further, missiles are one-shot devices that provide little field-service data to establish the degree of human-initiated failures.

In studying malfunctions in nine Air Force missile-system test programs, Stanford Research Institute discovered that little, if any, systematic human-factors performance testing is done. There was little pertinent data on human-initiated malfunctions.

A total of 4248 malfunction reports in nine projects were analyzed to determine the proportion of "equipment" failures and "holds" actually caused by human failure. They found as many as 53% of the equipment failures and 23% of the unscheduled holds were human-initiated—and these figures are probably low. Faulty reporting practice probably permitted some human-caused troubles to be classified as non-human to avoid guilt.

For example, one "overload" failure actually resulted from connection of a 28-volt unit to a 110-volt source; a "scrubbed" launch resulted when a technician put a plug into the wrong one of two adjacent, identical receptacles.

In detailed analysis of 1391 malfunctions on one missile, only 3 were labelled as human errors, but 322 actually were; of 977 on another, none were reported as human errors, but 195 were. Design was not at fault, but appeared to be.

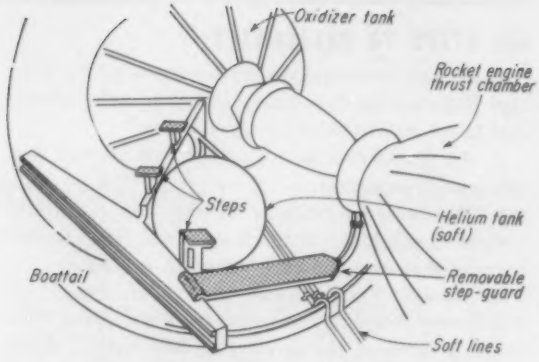
In an earlier study of rocket-engine damage, 35% of 600 reports showed human failure during maintenance, checkout and transport that caused damage or malfunction to a missile. Of these human failures, nearly a fourth were the result of improper torquing—because design did not permit sufficient space in which to use a torque wrench.

Improper routing of lines and placement of struts is a major cause of "inadvertent" damage. Inconvenient or inadequate foot and hand holds result in bending or crushing of members; limited working space causes tools to strike and damage exposed tubing. Contamination

THE CASE OF THE NON-PROTECTORS

■ Design of a room air conditioner incorporated a protection device for the motor. Motor burnouts were reported by field-service personnel, so motors were suspect. Laboratory tests showed good R in both motor and protection device. But a suspicious R man discovered that burnouts were occurring almost entirely in units installed in private homes. In industrial or commercial buildings with well-regulated line voltages, R was high; in private homes, where line voltages may fluctuate over wide limits, R was low. It became obvious that the motor protectors were the culprits—they were not expected to function in apartments, failed to function properly when there were frequent wide voltage swings.

Moral: Don't be misled by the apparent success of a "good" component in previous products—it may never have been loaded or stressed. In a new design, assume every component to be guilty until proved innocent. ■



LIGHTWEIGHT STEPS and removable step-guard protect soft hardware and provide accessibility to components in horizontal boat tail of a missile.

MISSILE DAMAGE FROM HUMAN FACTORS

1. Damage (nicks, gouges, dents, dings, bends)	65%
a. Installation or removal of a component	11%
b. Tubing used for foot or hand holds	2%
c. "Inadvertent" equipment or tool contact	16%
d. Procedural errors	10%
e. Handling techniques—engine	21%
f. Reversals (leads, components, tubing)	3%
g. Cross-threading	2%
2. Over-torque	22%
3. Under-torque	3%
4. Contamination (dirt, sand, lint, etc.)	10%

(particularly from sand!), poor maintainability and unnecessary complexity are lesser, but still important, problems.

make it idiotproof

Design should provide removable steps and guards to prevent service crews from damaging tubing or other vital elements in servicing. Special marking of components or application of instructions on parts or subassemblies has helped reduce faulty installation. Better still is redesign for "one-way" connection through varied physical mating elements. Redesign of ground-handling equipment, and packaging to prevent damage in storage and transit, have also been necessary. ■

SECOND CASE OF THE DISCONNECTING CABLE

■ A connector on the coaxial cable in the radar portion of a supersonic fighter disconnected in flight because of vibration. A screw-type connector solved the problem. But on the next model, the very same mistake was repeated! Communications in the design department fell down.

Other cases include lack of safety wiring, lack of drainage for water of condensation, routing of wiring too close to sharp edges, causing chafing and exposure of vital surfaces to corrosion.

Moral: Correcting an unreliable design is not enough. The information gained must be retained so the next design will not make the same mistake. Experience data must be drummed into everyone or good design will be violated repeatedly. ■

R *the importance of failure analysis*

Testing and statistical analysis can frequently be applied to components and systems, but unless the completed product is manufactured in large quantities, is short-lived, is relatively inexpensive, and a long testing period is possible, testing a number of completed units to destruction is impractical. The substitute—and a very practical one it is—is to obtain detailed failure reports from the field and to analyze them for the needed data.

The first essential is to train sources so the failure reports are thoroughly done. This requires development of detailed instructions and a report form that is not open to confusion. The second step is to be certain every failure is reported and that the correct reasons are given, at least to the limit of the reporter's ability. There is a tendency, for example, to assign other causes than human misjudgment or mistreatment to a failure, so that design may be held responsible when some other factor is at fault.

The major problem is to obtain sufficient detail and precise data, particularly if the failure is catastrophic. The wrong order of events may be assumed, or the failure may simply be stated without any description of environments or events just preceding the failure.

Given adequate data, trained R men should be able to analyze failure reports and arrive at statistical data that in some respects are superior to lab testing—because they cover actual rather than test environments and treatment.

Failure is the business of test crews—they learn that way. Many missile launchings that "failed"—according

to the newspapers—gave tremendous amounts of information. With instrumentation and telemetry, causes of failure can be established even when the test "piece" is destroyed or lost. Here are some examples:

• An Atlas missile failed from a short circuit on the vernier feedback transducers which gave false signals to the main guidance system. The short was caused by aerodynamic heating at the base of the vernier fairing.

• On early Thors, exhaust gases backfired to burn out main engine controls. More recent ones have had problems of metal fatigue in welded tank joints, and valve-freezing from the —297 F temperature of Lox.

• Bomarc had one failure caused by dampness in the guidance system. It indicated "nose down" when the missile was actually on course. The guidance control pulled the nose up to correct. Result: two tight loops and a smash into the blockhouse.

• Project Far Side (firing through a balloon) had troubles because of (1) a short circuit in the firing system, (2) bursting of the balloon from the cold, (3) destruction of the rocket instrument package in launching because it hit a thick nylon grommet at the top of the balloon.

• And several missiles have committed suicide—the safety system which destroys them if they malfunction itself developed a malfunction. ■

SIX STEPS TO RELIABILITY

A Reliability control system developed by the General Engineering Laboratory of GE in Schenectady and based on statistical study calls for:

1. *An Accelerated Life Test* for both current and long-range programs.

2. *Monitoring System* to provide the numerical indices of reliability, with all other data statistically correlated to evaluate their effect on reliability.

3. *Normal Test — Accelerated Test Statistical Evaluation Program* conducted to establish the relationship between the accelerated and normal tests.

4. *Organization of In-Process Data* to integrate all the activities related to the Reliability control system, including pertinent vendor's operations.

5. *Organization of Field Data* integrated to the final test and inspection systems.

6. *Presentation Methods* to guide each member of the reliability teams.

Adapted from a paper, "Statistical Approach to Reliability Improvement," by N. P. Demos, presented before the IRE, March 21, 1960.

THE CASE OF THE STOPLIGHT SWITCH

■ Some years ago, in the new model of one familiar car, the stoplight switch promptly failed. The replacement cost only 25 cents, but installation cost $12, because the designer had located the switch inside the crankcase, so it was necessary to drain the oil and drop the oilpan for each change. And the oil splashing on the switch caused the carbonization that knocked out the switch.

On the same model, sparkplugs were found to be too small for the new engine, so the maker had to call back early models and rebore cylinder heads to take larger plugs. Cost: about $50 per car.

Both of these faults were the result of rush design, with inadequate testing procedures before production release. There is also more than a little evidence that the designers had little or no practical experience. A reliability group, with its separate and unbiased approach and preponderance of practical people, would have spotted these errors quickly. ■

THE CASE OF THE LADY DISPATCHER

■ Test crews at Edwards Air Force Base were elated at results with Navy's Regulus I, a high-speed pilotless bomber. Then, for no reason, it began to pop its drag chute (a small parachute to slow landings.) The crews dismantled the chute-release system and its radio control circuit. Both were functioning normally. Then somebody noticed the missile never misbehaved until 5 o'clock or after. The mystery deepened, until it was discovered that, several hundred miles away, a woman dispatcher took over at 5 for a local radio-cab outfit. By a million-to-one electronic freak, her voice was just the right pitch to modulate into the frequency used by the EAFB test crew to signal parachute release. As soon as she dispatched her first cab over the air, pop went the chute.

Moral: Cherchez la femme.

Canaveral had a similar case, in which a forest-fire-fighting party out West suddenly "invaded" the frequency for control of a rocket about to be launched. Canaveral's radio room tried to persuade the firemen to switch. "The hell with you!" was the reply. "You're on our frequency. You change!" (Canaveral did.) ■

THE CASE OF THE THREADED FASTENERS

■ More than 1200 auto crashes in New Jersey were traced by motor-vehicle officials in a recent report to loosened fasteners. There are at least 100 critical threaded fasteners in each vehicle—a total of 5 billion potential sources of failure.

Tests made by Standard Pressed Steel on fatigue of bolts have resulted in S-N curves for each type, size and material. A particular capscrew, for example, can take 100,000 load impacts of 57,000 psi. If load impacts increase to 1,000,000, load limit is only 28,000 psi. Various other companies are also producing similar charts for their mechanical components, leading the way to adequate data for reliability calculations. ■

THE CASE OF CONICAL NUTS

■ Chevrolet trucks, like most cars, had wheels mounted on hubs through bolts. Nuts on these bolts were made conical, to fit in similar recesses in the wheel and fix wheel location.

Inevitably, minor variations in the placing of the bolts occurred in production, and other minor variations occurred in the countersinking of the holes on the wheel. This resulted in unpredictable eccentricity of the wheel, which becomes more pronounced – and unacceptable – as truck speeds and wheel rpm's increase.

In the 1960 models, the design has been changed. Now the wheel is located on the hub by means of five locator lands over which the central wheel hole fits snugly. The bolts only act to hold the wheel, not to position it. Tolerances on location of the hub bolts and matching holes in the wheel can be relaxed, and the wheels no longer need to be balanced, nor do they exhibit eccentricity, run-out, etc. The hub hole is the reference point for all machining operations. ■

measurement vs calculation of Reliability

In developing a product to a reliability standard, you face a series of dilemmas. If it's a simple product that fails fairly rapidly, you can arrive at statistical results by testing enough products to destruction until you reach a consistent rate of failure or mean time to failure.

But very few products come in this category; most are complex, costly and designed for a service life long enough to make the necessary number of engineering tests impractical. At some point or other, you must abandon tests and make assumptions—or calculate the reliability.

A limited number of tests means a similar limitation of confidence in any estimate of product life based on the tests—the smaller the number of trials, the lower the confidence level. Yet engineering decision for redesign must be based on these data—as well as company decisions on the length and type of warranty that can be offered on the product and the number of units to be set aside as reserves to cover in-warranty failures.

failure—causes and types

There are four basic causes of failure in service:

1. Infant mortality, usually the result of faulty materials or manufacturing errors not detected by the various inspection procedures. "Run-in" should detect these failures, a mild increase in environment stress may precipitate them in the first few minutes. Another method is aging —standing in storage—but this procedure can damage other parts.

2. Chance, random or constant hazard caused not by wear-out but by the vagrant chip, the extra drop of solder, and an endless number of unknowns. Statistics show the probability of such failures, but we don't know why or when until after the occurrence. Something akin to this is the automotive "lemon," which never really works well, through an unfortunate combination of marginal-tolerance parts or similar causes. Chance failures easily can be mistaken for wear-outs, thus corrupting failure data—like accidents and virus in humans.

3. Misuse beyond the intended purpose violates the limits, hence destroys reliability wilfully—akin to homicides or war casualties in humans, drag racing or beating a traffic light when driving a car.

4. Wear-out, epitomized by the "one-hoss shay," is that in which all parts fail at once. These failures are caused by aging and fatigue—the parts drift out of tolerance after long use, they rust, or become inefficient. This is progressive reduction of product capability until the unit is degraded beyond the point of usefulness. Wear-out can be postponed by proper preventive maintenance.

Idealized product life cycles are usually visualized as on the chart shown below, although they actually vary individually in detail or basic shape. The manufacturer is concerned about the infant mortality because this represents faulty manufacture and both costly and embarrassing replacement or scrapping. The customer wants a long central period of trouble-free life before wear-out occurs—7 to 10 years for a clothes washer, 20 years for a turbine. Neither usually cares about the shape of the wear-out curve—as long as it is compact.

To arrive at the essential figures—low failure rate—requires enough life testing for a high confidence level or calculating by mathematical methods backed up by limited proof testing to check. Design in an iterative developmental process, in which testing is a feedback device to guide redesign, re-examination and restatement of design objectives until an acceptable design is achieved. So, if testing is to be limited, it should be correspondingly more thorough, with "elegant" instrumentation. Also, on complex testing of parts and subassemblies as they are de-

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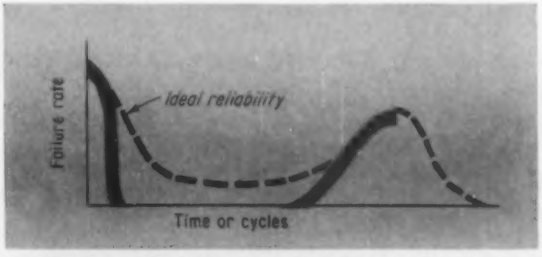
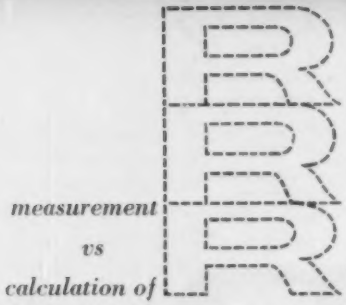


DESIRED RELIABILITY PERFORMANCE foreshortens infant mortality and defers start of wear-out failures.

THE CASE OF THE FAULTY GIMBALS

■ Mechanical oscillation of gimbals caused 32% of gyro failures on North American's airplanes, resulting in noisy outputs. The remedy is better gimbal arrangements resulting from thorough vibration testing in the prototype stage. Another 5% of failures resulted from excessive friction from the potentiometer wiper arm, caused by worn arm bearings or buildup of foreign matter on pot windings. Inductive pickoffs (AC) rather than pot pickoffs (DC) are the answer.

Moral: It may not be the component, but the holding method, that is faulty in design.■



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veloped can raise confidence level on these elements at least, with relatively lower cost.

Two faulty assumptions are frequently made about testing: The first is that there is no distinction between a proof test (a demonstration that the product meets specifications) and an engineering evaluation test (see the page on jargon). Actually, the proof test generates no engineering design information: it is purely a sales demonstration. Secondly, the assumption may be made that logical analyses can replace testing. They do not—they merely point the way. (In one case, a missile kept breaking up in air. Finally, enough tests were run to identify the trouble as analytically unexpected torsional bending stress.)

Engineering test programs should include:

1. Making predictions about performance of the tested components or assembly, based upon interpolation or extrapolation of established data.
2. Designing tests to prove these predictions.
3. Instrumenting the unit and the area to acquire pertinent data for evaluation of predictions.
4. Evaluating and comparing predicted with actual performance.
5. Analyzing discrepancies between predictions and empirical results and modifying design of the model from which predictions were made.

test versus experiment

Development testing and traditional research experimentation are, and should be, different. Engineering test seeks an "adequate" design that meets objectives, not "good" or "optimum" design or the collection of basic data—that's the research problem. Engineering test is less precise because of time, cost and number of samples; it deals with operational realism. Experimentation in the laboratory, on the other hand, achieves high precision by designing a situation in which all variables can be controlled—hence is limited in number of variables and loses operational realism. Test locates unforeseen problem areas that research must investigate, gives rough answers quickly.

Generally speaking, about 30 failures are considered enough to permit an estimate of product life behavior. It is quite obvious that on more-expensive products, this number will be arrived at, if at all, only by observing units in use by customers.

On more-complex products, more tests are theoretically necessary. For example, the German engineers who developed the V-2 made 300 flight tests to get desirable performance characteristics. But, because of their experience with the V-2, they found only 50 flight tests built adequate performance into the Sergeant missile design.

Testing is not always the practical method for obtaining reliability data. The design life may be too long, the cost too great, the time too short. Then reliability must be arrived at by calculation, just as other characteristics are. The procedure is similar to that in progressive testing —calculation of reliability for each component in the expected environment, then the reliabilities of components are combined to get those of subassemblies, and so on.

After all, the calculating procedure is quite familiar. Testing is still necessary, but far smaller numbers of test pieces are required. The tests merely confirm the calculation of product life; they do not establish it. They can be omnibus tests, too, checking complex assemblies.

Calculating reliability (see later section) has saved much time and complexity for the Services. For example, the current missile programs could all still be bogged down in preliminary testing, because the life behavior in test will follow that of the worst component. Even though the "weakest link" is discovered promptly, time would be lost in redesign and retest. The reliability analysis will normally uncover these weak links and suggest redesign before the tests start. ■

THE CASE OF THE HANGAR QUEENS

■ When the US entered World War II, we had had some experience in producing planes for the British, but not in real quantities. So we began a program of high production with concurrent improvements in design. Because of combat demand, all available planes were shipped out; there was neither time nor equipment available for adequate testing. As a result, we did not know what spares were required and in what relative quantities, and designs changed so rapidly that all hope of interchangeability was lost. Spares were likely to be whatever the maker had extra—rivets, tanks, or what have you. Combat units stripped parts and assemblies from damaged planes to keep others flying, made their own design modifications in the field. As a result, every field had its "hangar queen," planes that served as stock rooms for the others—rather than flying missions. Toward the end of the war, an interchangeability study on two planes, each from three plants making the same bomber, showed that each plant had gone its own way, making modifications without regard to the others. Thus, practically no parts were interchangeable.

In contrast, the British built parts in "shadow" plants to a prototype design. No plant could make modifications without approval from the Ministry of Aircraft Production (MAP), and then only on terminal parts. Other changes were tested, then graded for importance, so they could be installed on *all* planes of that type, wherever stationed, at some predetermined date. Thus all components, wherever produced, were kept interchangeable. Further, all new designs were thoroughly tested before release to combat, so failure characteristics and spares needs were known. Further, unless needed spares were provided by the builder, the planes would not be accepted, and planes were not flown in combat until adequate replacements and spares were available.

This was, in effect, a reliability program in the face of an extremely difficult situation. Time is always the enemy of reliability; it does not permit design refinement or testing for improvement. The American choice, under these conditions, was to produce in quantities and expect waste in use; the British was to produce in smaller quantities, to modify slowly, and thus to extend combat life of units. ■

statistical tools for Reliability tests

Statistics are a vital tool in reliability operations because there must be a quantitative measure before a design trade-off can be made. But statistics, like any other tool, must be tailored to the problem, not the other way around. And "a little statistics" is worse than no statistics at all in solving R problems, just as a little knowledge is dangerous in any other field.

Statistical tools can be used for investigation, problem solving and control only if they're understood. This requires personnel skilled in statistical methods. Some companies have hired statisticians or mathematics majors, others have provided special training for engineers or are training new engineer graduates in statistics.

Sampling techniques, complex experimental designs, regression analysis and correlation analysis are being applied. The Graeco-Latin square, for example, solved a problem in receiver circuitry for Texas Instruments in 275 measurements that would have required over a million by the old trial-and-error technique.

More than just a tool for predicting failure hazard, statistics also crops up other places in the reliability program. It is, in fact, the cornerstone on which all efficient testing programs are built. Statistical techniques help engineers plan experiments with many variables that yield the most information for the fewest tests and cut experimental time and expense.

Suppose the problem is to design a hydraulic circuit with two valves, three cylinders, and a control circuit (linked to both through a feedback loop) and suppose there are five different kinds of valves, four types of hydraulic cylinder and three configurations of control circuit to choose from. Which combination gives best reliability? Or, in bearing design, what combination of such continuous variables as load and temperature will give a bearing with the longest life?

Fastest answers can be found with statistically controlled experiments. With statistics, it is not necessary to test every combination of the different hydraulic components (60 tests in all). Nor will the statistically aware experimenter find maximum bearing life in the traditional way; that is, by holding the first variable constant and varying the second to find its best value, then holding the second at this level and varying the first to find the best value for the combination.

Experimental designs are generally of three types: Latin square, fractional factorial, full factorial. Oldest and most elementary of these is the Latin square. It derives from a puzzle game several hundred years old and reduces an experiment with four levels of three variables, for example, (64 possible combinations) to only 16 tests. The Graeco-Latin square is an extension of the same technique to include experiments with more than three variables by assigning Greek letters to the other variables and combining them with the Latin-lettered variables.

The limitation of the Latin square is that it is valid only when a change in one variable has no effect on the others. Such interaction effects, if they are present, cannot be measured. By increasing the number of tests, however, a fractional factorial experiment can be set up to measure certain preselected interactions. Or all interactions can be segregated and measured with a full factorial—a design that includes all possible combinations of all variables. Although the full-factorial design effects no saving in the number of experiments that need be performed, its statistical makeup insures maximum information and proper interpretation.

When variables do not have discrete levels but are continuous functions, there is potentially an infinite number of combinations. In this situation, the experimenter may begin by assigning arbitrary discrete levels and combining them in a Latin square or fractional factorial to get a rough preliminary estimate. This can then be refined by regression analysis—a statistical method for fitting the best curve to a group of experimentally derived data points. A plot of three variables, for example, will give a three-dimensional surface (called a "response surface" by statisticians) representing the relationships between the variables. The exact mathematical shape of this surface can be found by reducing the data from the preliminary experiment to a set of regression equations. The equations show the best combination of values for the variables.

statistical prediction

While there is nothing wrong with the idea and statisticians have great hopes for it, statistical prediction is *not* reliable; it offers only a rough comparison or an indication.

Relative reliability can compare a known and a new design but even this must be proved by test. As Air Force letter 84-1 says: "The first predictions or estimates of reliability, made in a feasibility study or in the project's pre-hardware phase, will be derived mainly by using analytical production techniques, and they may not inspire a high degree of confidence. But as reliability-prediction techniques improve, and as revised estimates increasingly reflect the results of component-testing programs, they can be used with growing confidence."

The future probably lies in statistical prediction of environments or stresses, because these cannot be predicted particularly well even in destructive or life tests (reliability evaluation tests). It is difficult, sometimes impossible, to duplicate environments in a laboratory, yet on some me-

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chanical products, working and surrounding environments are vitally important. The only alternative is analysis of field failures.

One group head points out that there is an interesting parallel in "fashions" in drugs and in use of statistics. Back in the Thirties, the fads were vitamins and stress analysis; in the Forties, they were sulfa drugs and statistical quality control; in the Fifties, they were antibiotics and statistical reliability. Each has been an essential part of any nostrum —and then the fashion has changed. There is, in each case a net gain after the faddishness is shaken out. This group head feels statistics will have a strong place in reliability work in the Sixties "because we still need new approaches to the value of a product." But these approaches will be based on added experience and knowledge, so that reliability can become a "lubricant—with teeth—between all of the departments included." ■

STATISTICAL METHODS FOR PROGRAMING TESTS

The methods described in the text have been discussed in several earlier articles in PRODUCT ENGINEERING. For more details, see:

Design of Experiments—Blind Spot for Researchers, Sep 22 '58, p 34. The reasons statistically designed experiments are faster, give more information, than those conducted along classical lines.

Latin Squares for Fewer Tests, Same Accuracy, May 12 '58, p 92. An example shows how it cuts experimental time to the minimum.

Experiments That Have Statistical Certainty, July 6 '59, p 66. How to set up a full-factorial experiment and interpret the results.

Ready-made Design Simplifies Multivariable Experiments, Dec 21 '59, p 56. A cookbook method for designing a fractional factorial experiment.

Regression Analysis Digs Out Equations From Scattered Data, July 20 '59, p 62. A step-by-step explanation of the Forward Doolittle method for fitting an equation to many data points.

3 Shortcuts for Comparing Test Results, Feb 15 '60, p 72. Charts developed by statisticians simplify finding correlations or differences between sets of variables.

Find Statistical Deviation Faster—With Vectors, May 9 '60, p 43. Graphical method shortcuts numerical computation.

mathematics of probability R

Reliability is a prediction—hence it must be expressed as a probability. We are concerned here with the number of failures (called *events* in probability analysis) in a given number of identical test runs (called *trials*). Let's work with a concrete example:

You want to know something about the reliability of a new automatic parts feeder. In the first hour under test it delivers 100 parts (trials) but 10 parts come out wrong side up (failures). The failure rate determined in this way is 10%. This is called *empirical* probability—it was found by actual test.

Let's assume the parts are cubes, with drilled holes in all faces but one. A failure in delivery is defined as a cube which comes out with an undrilled face up. We can calculate that the probability is one failure for every six cubes—a theoretical probability of failure of 16.7%. This is called *a priori* probability. Predicted by logical analysis, it is the figure that empirical probability approaches with an infinite number of trials.

Probability has a standard notation as well as a series of useful laws. The *multiplication law* refers to the probability of two or more independent events both occurring in one trial. If independent events A and B (say, failure of gear teeth and failure of bearing, in a gear-box) have probabilities $P(A)$ and $P(B)$, the probability of both occurring in a single trial is

$$P(A \text{ and } B) = P(AB) = P(A)\,P(B)$$

If the independent events A and B are mutually exclusive—if they *can't* both occur at the same trial—you might ask, what is the probability of *either* gear failure or bearing failure? Then the *addition law* applies

$$P(A \text{ or } B) = P(A) + P(B)$$

If the independent events are not mutually exclusive —failure of gears and failure of bearings are both possible (as in the multiplication law)—and you wish to know the probability of *either* or *both* occurring, then

$$P(A \text{ and/or } B) = P(A) + P(B) - P(AB)$$

The reason for the subtraction is that $P(A \text{ or } B)$, which

is what $P(A) + P(B)$ is, includes two counts for each time an A and a B occur together, one for each probability. So to calculate (A and/or B) you subtract one of the sets. Similar reasoning applies to higher-order summations made by adding one variable to the above equation.

$$P(A \text{ and/or } B \text{ and/or } C) = P(A) + P(B) + P(C) - P(AB) - P(BC) - P(AC) + P(ABC)$$

Now suppose the two events are not independent. Suppose the second cannot occur without the previous occurrence of the first—perhaps you've rigged a signal light to turn on when the gear fails and you want to know the probability of the signal light failing to indicate a gear failure. Then

$$P(AB) = P(A)P(B/A)$$

where $P(B/A)$ is the probability of B occurring, assuming that A has already occurred.

variable probability

The preceding discussion deals with the probability of occurrence of an event. But in reliability work, such a probability may vary because of external stresses. Therefore, the probability usually must be expressed as a function of time. The function must have a real value, must be between zero and one for all real values of the variable.

Further, there may be multiple stresses, each a variable: vibration, shock, temperature, etc. It would be simple if these stresses could be separated—then the total probability would be the product of the probabilities of each stress occurring. But this is usually not possible.

Fortunately, the events with which engineers are concerned here are either successes or failures—there is no in-between. So the probability of success and the probability of failure are mutually exclusive events; their sum must equal one.

safety factor vs time to failure

Industrial practice, like Army practice, is to specify a safety factor, or safety margin, to attain reliability. Safety margin is defined as mean strength minus maximum operating stress divided by standard deviation of strength (see math below).

Some contracts even specify "all parts to be over 6σ" (six times standard deviation). But this can give overweight, overcost and overdesign. The Air Force and some R men have found it more economical to specify an operating condition, or mean time to failure—indicating how much failure is permissible. Thus a part easily replaced and not critical may have a low of σ. The result is "balanced" design, with some parts 6σ, and some 2σ.

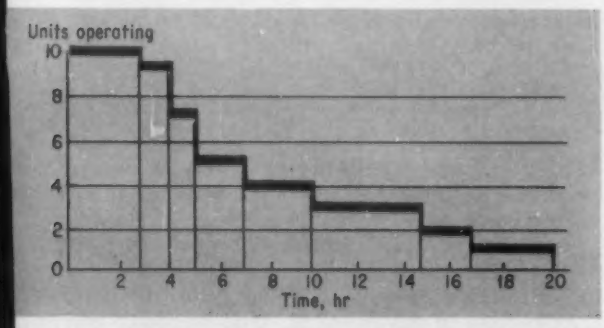

Fig. 1 Histogram shows failure rate.

To arrive at mean time to failure on an accelerated basis, some companies are now stressing the technique of "search for critical weakness"—testing in environments exceeding qualification levels—to see how much *margin* the design has and where the weak spot is. Even a missile has margins, some always larger than calculated because they allow for a *combination* of environments that is almost never encountered.

Let's assume 10 operating units are tested to failure. Their operating times are 3, 7, 5, 10, 17, 4, 5, 20, 15 and 4 hr. The mean-time-to-failure (MTF) would be:

$$MTF = (t_1 + t_2 + t_3 \cdots + t_n)/n$$
$$MTF = (3+7+5+10+17+4+5+20+15+4)/10 = 9 \text{ hr}$$

This may be pictured in a histogram as shown here. This diagram, Fig. 1, shows graphically that half the units had failed in 5 hours—or 25% of the longest operating time, and that for the last half of the total period only a third of the units were operating.

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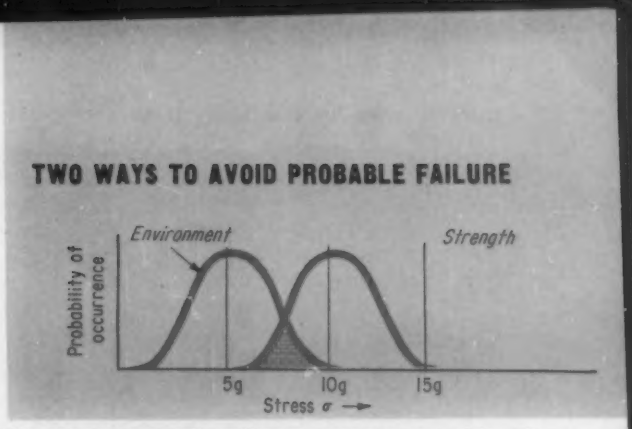
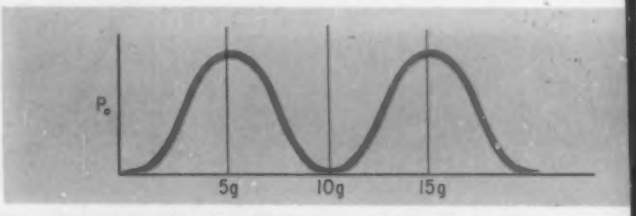
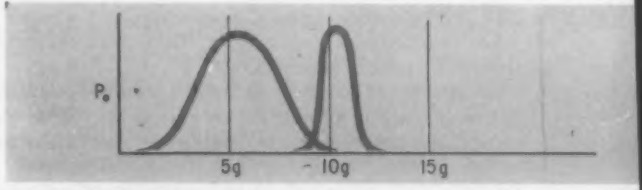


Suppose environment applies an average stress of 5g. The component can withstand 10g. The overlap at 7 to 8g creates a possible failure zone.



You can increase the strength of the component to 15g and remove the area of overlap. This is in effect what is done when a part is derated.



Or increase the quality of the component and holding tolerances closer. This narrows the base of the strength curve so it does not overlap the environment curve.

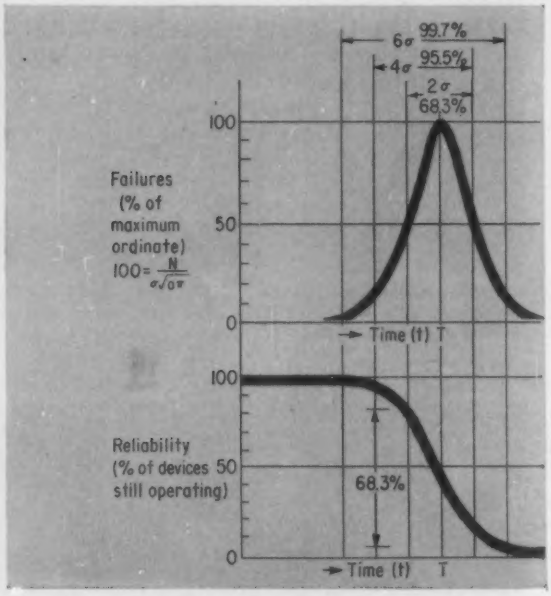


Fig. 2 **Wear-out failure** gives a normal distribution curve which is centered around mean time to failure.

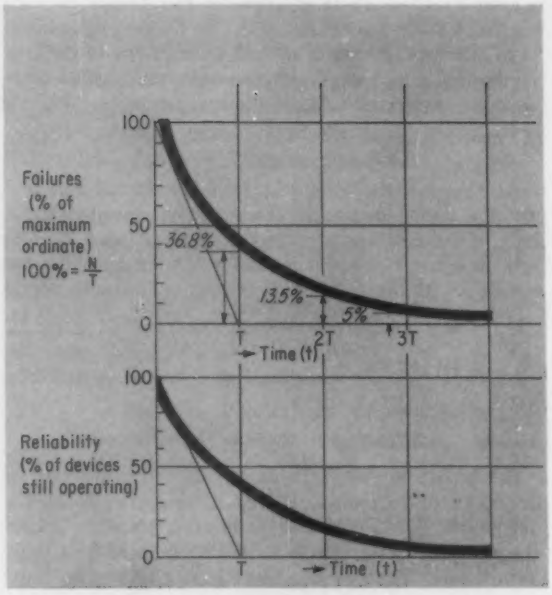


Fig. 3 **Constant-hazard-rate** failures have equal chance of occurring during lifetime of the mechanism.

the math

Let's take a quick look at some of the more elementary statistical concepts in reliability.

Wear-out failures tend to take a normal probability distribution about a mean life time (Fig. 2). The exact curve shape and location are described by two parameters: σ, the standard deviation; and T, the mean time to failure.

The standard deviation of a given failure distribution tells how widely spread the failures are likely to be in time. You calculate standard deviation

$$\sigma = \sqrt{\frac{\Sigma(T-t)^2}{N}}$$

where T is the arithmetic mean, t is the time of any particular failure, N is the total number of failures and σ is the standard deviation.

The consequence of this type of failure is a reliability function which is one minus the integral of the failure distribution. This plots as the percent of devices still operating at any particular time, as in Fig 2.

Constant-hazard-rate failures are equally likely to occur at any time during the life of a product. Suppose you've reduced this type of failure to a minimum of 10 per 100 operating devices every 100 hours. Starting off with 100 devices you lose 10 in the first 100 hours, 9 in the second 100 hours, a little over 8 (8.1) in the third 100 hours, etc. This plots as an exponential curve in Fig 3.

$$y = \frac{1}{T}\, e^{-t/T}$$

where T is the mean time to failure, y is the number of failures occurring at time t. Again, the reliability function is one minus the integral of the failure distribution.

In all these formulas you multiply y or R by the number of devices in your sample (N) to get numbers specifically applicable to the problem at hand. However, in this general form we're better off dealing in percentages because several such curves—each applying to a single component—will be combined in the reliability analysis of a complete product.

combination effects

Suppose a product is made up of several components with differing failure characteristics. The probability distribution of wear-out failures will be different for each type of failure. There will be constant-hazard-rate failures, but again, each type has its own time characteristic. How do you combine them to find an over-all reliability function, and how do you account for interaction effects?

The reliability of a system is equal to the product of the separate reliabilities of its components.

$$R = R_1 \times R_2 \times R_3 \times \cdots$$

To find the system reliability curve, pick off the reliability of each component at a particular time, multiply them, and plot the product for that time on the new graph.

the importance of confidence level

Mistrust such statements as: the equipment is 90% reliable; one failure in 200 trials; 100 assemblies operated without failure. In all three cases, the number tested may be too small. For example, if only one failure occurred in 100 tests, the apparent reliability is 99%. But if No. 101 fails, the reliability drops to 98%. If 10 parts failed in 1000 tests, reliability is also 99%, but if No. 1001 fails, reliability drops off only to 98.9%. If no confidence level is stated, the value for reliability doesn't mean much.

Or again, the statement is made that "this unit will

operate without repair or maintenance for X hours." This usually means that mean time to failure is X hours—and probability of troublefree operation to X hours with a constant-hazard failure is only 36.8%. Again, confidence level is at fault. Statistics can help here—by determining the number of tests necessary to achieve a desired confidence level.

a typical problem

Here's a sample of a reliability calculation. The mechanical aspects of an electric motor are under examination in the hope of offering a 500-hr guarantee to customers. The motor has two brushes, two ball bearings and a small fan on the shaft to draw outside air around the field coils.

An analysis of electric failures (insulation breakdown, overload, burn-out) is known to be of the constant-hazard type, for all practical purposes, with a mean time to failure of 20,000 hr.

The brushes have a sharply peaked wear-out failure characteristic centering on 1000 hr and with a standard deviation of 200 hr.

The bearings have a more broadly spread wear-out failure characteristic, centering on 1800 hr with a standard deviation of 600 hr.

Unpredictable mechanical failures of the constant hazard variety—abrasive dust on the commutators or bearings—set mean time to failure at 10,000 hr.

Note that both mechanical and electrical unpredictable failures have very long mean times relative to the wear-out failures, but because of their even distribution in time an annoyingly large number will fail before wear-out failures takes over.

The most pertinent question is: What percentage of motors will still be running at the end of 500 hr? The answer is simple to calculate as a product of the component reliabilities at the time as in Fig 4.

Electric failures will leave 97.5% operating.

Unpredictable mechanical failures will leave 95.0%.

Each brush has a reliability of 99.4%.

Each bearing has a reliability of 98.5%.

The last two figures were derived from normal curve area tables available in most statistics reference books.

The total motor reliability is thus:

$$R = 0.975 \times 0.950 \times 0.994^2 \times 0.985^2 = 0.887$$

This is hardly a very happy figure. The manufacturer would not be anxious to guarantee to repair 11 out of every 100 motors sold.

The wear-out failures of bearings and brushes account for a combined reliability of 95.9%. This is a reasonable figure, and a small improvement in the bearing life (a new grease? a better surface finish?) might well raise the wear-out reliability to over 98%.

The unpredictable electric and mechanical failures cause more serious trouble. The mechanical engineer can point to the electrical problems (causing a reduction to 97.5%) but his own 95% contribution is even worse.

Suppose the bearings were shielded to keep the grease in and the dust out. This might increase wearout life to 2500 hr mean time (with the same σ of 600 hr) and simultaneously double the mean time of unpredictable mechanical failures from 10,000 to 20,000 hr (Fig 5).

Then each bearing would have a wear-out reliability of 99.9% at 500 hours and constant-hazard mechanical failures would have a reliability of 97.5%.

$$R = 0.975 \times 0.975 \times 0.994^2 \times 0.999^2 = 0.936$$

This is a very substantial improvement. But perhaps the manufacturer is willing to contract for only one repair job in 20—a reliability requirement of 95%. What lifetime could he guarantee?

For this a full lifetime plot would have to be made as shown—the answer is 440 hr. ■

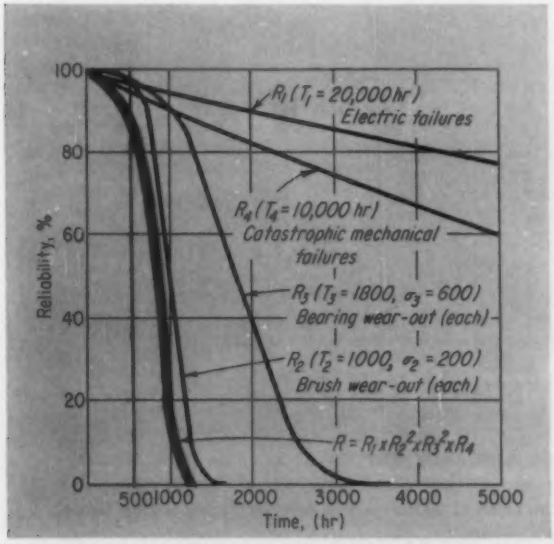


Fig. 4 Electric motor has four parts with different reliability functions. At 500 hours, over-all reliability is only 88.7% mostly because of unreliable bearings and brushes.

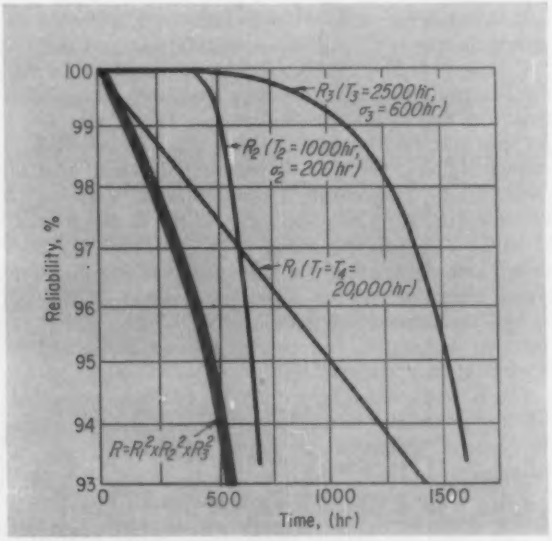


Fig. 5 Improved motor with sealed bearings reduces wear-out hazard and possibility of unpredictable mechanical failure. Over-all reliability is increased to 93.6%.

the Reliability organization

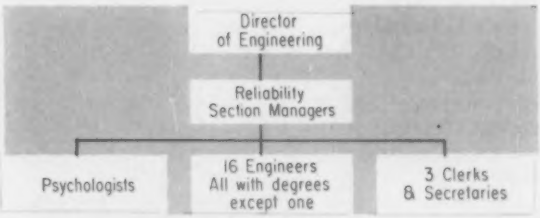
Any reliability program can only be as good as the organization that administers it. Like morale, reliability filters from the top down, is not built from the bottom up. Thus the R program must be strongly administered and supported from the top if it is to succeed. *Direct action* and *control* are essential; both must be authorized by top management.

This has led most companies with R programs to administer the program through a top-level policy committee. Typical composition might be the top operating executives of each department, headed by the chief operating executive of the company or division. This group establishes R policy and sees that it is implemented. It may actually control the program or—this is often done—control through a committee of key operating men from Engineering, Production, Purchasing, Inspection and so on, headed by a chairman picked from their number and rotating on a regular cycle of three or six months. Committees hold regular meetings and present reports, and their composition and activities are publicized at least through all management levels.

Actual operation of the R program is usually in the hands of a specialist group with no other responsibility. Organization varies with company and with product, but in general **the reliability group is in the engineering department, and the preponderance of its personnel are engineers.** In fact, in smaller organizations, only the engineering department may have full-time reliability men—an indication of the relative importance of R thinking in design, as compared with R in manufacture and use.

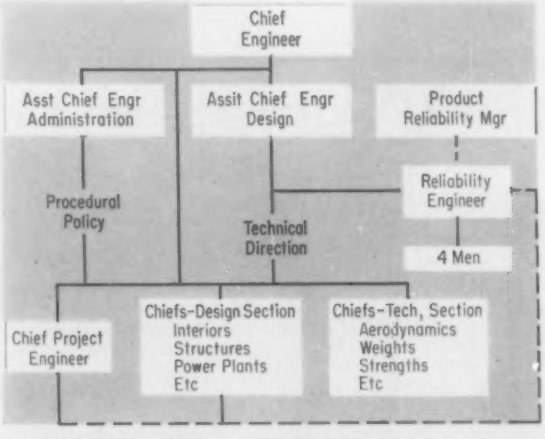
Certain general principles should be considered: First, the R organization will differ in a multiproduct organization from that in a single-product one. Second, the number and size or complexity of product will influence it strongly. Third, the type of organization—functional or project (see "Engineering Organization in Transition," *PE*, May 11 '59, p 47)—will dictate the R organization as well. The selected group of organization diagrams shown here demonstrate the strong support and direction typical from the very top of the organization—evidenced in top-management interest, in a solid policy group or directing committee, and in the authority necessary to implement its operations.

The R group and program may be a fully implemented unit (as at Convair Astronautics) or avail itself of facilities such as laboratories or specialists available in older departments (as at AiResearch or Douglas–Aircraft Engrg). It may be strongly centralized or dispersed among departments; but even when dispersed, there is usually a central R advisor to coordinate the program and advise policy groups, (Autonetics, AiResearch). He may even be a part of some other group; North American

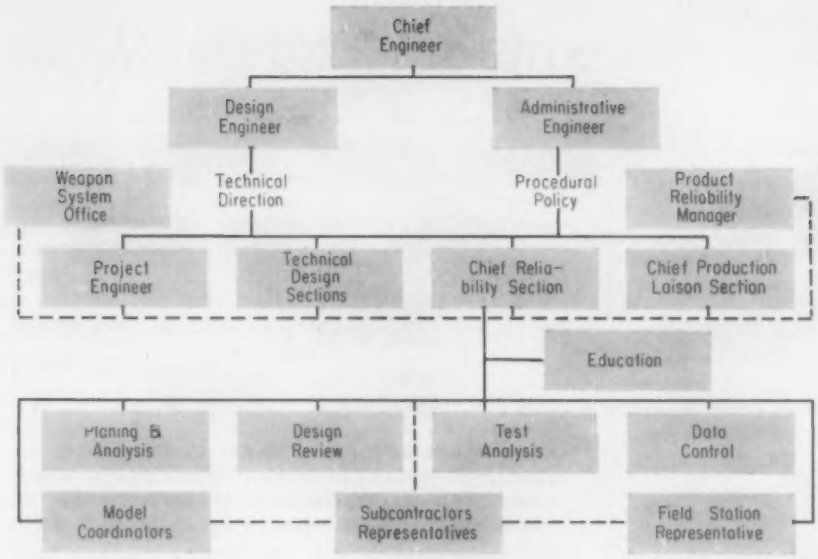


SUBCONTRACTOR GROUP—At Temco Aircraft, Dallas, the R Group is headed by a mathematician-engineer, is staffed by mechanical, electronic and aero engineers except for a mathematician and a psychologist. Emphasis here is on the qualitative rather than the quantitative side.

Aviation has its reliability coordinator in the corporate Quality and Logistics office. Each operating division has centralized reliability engineering groups. In multi-division corporations such as the Garrett Corp, a corporate level director reporting to the vice-president of engineering provides policy and guidance.



AN AIRCRAFT SETUP—At Douglas–Santa Monica, in the Aircraft Engrg Dept, this organization reflects the same thinking as the missile one (top, next page), but is smaller, puts responsibility for implementing the program up to section chiefs. The R Section coordinates progress, handles education and reviews all factors.



PRIME-CONTRACTOR SETUP—About 80 people form the Reliability Section of the Missiles & Space Systems Engrg Dept of Douglas—Santa Monica. Here the R staff takes principal engineering action to implement the R program.

essentials of successful R organization

1. Distinct, planned and organized program, realistic in its aims and scheduled in accordance with the product-development program.

2. Line responsibility for reliability at every management level, and for utmost cooperation to improve it constantly.

3. Continuous monitoring of R policies and problem areas by the top-level policy committee, with regular meetings.

4. A group specifically concerned with reliability, and nothing else, particularly in Engineering. It should be flexible in structure to meet changes in problem areas.

5. Headed by a reliability chief who has high-level authority, so the group can show its teeth if necessary.

6. Staff or group personnel of high technical ability, each with best backgrounds in at least one such area as physics, mechanics, electronics or human engineering.

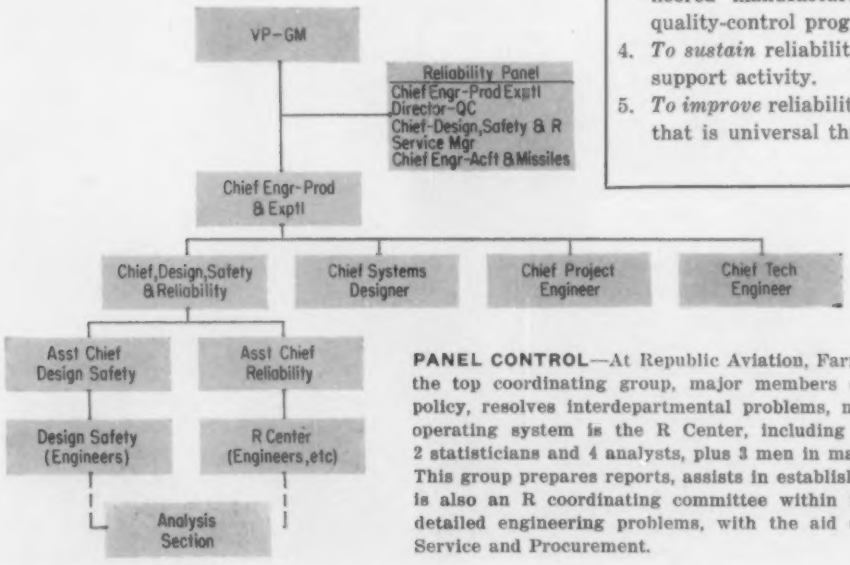
7. Continual re-indoctrination and refreshing of management knowledge and understanding of the subject.

8. Understanding by other personnel of such responsibilities as failure reporting, operating-problem reporting, suggesting changes in design or methods.

FUNCTIONS OF AN INTEGRATED R PROGRAM

1. *To establish* the reliability in the design.
2. *To verify* the reliability through a sound test program.
3. *To assure* reliability through properly engineered manufacturing processes and a tight quality-control program.
4. *To sustain* reliability by well-developed product-support activity.
5. *To improve* reliability through a feedback system that is universal throughout the program.

—Douglas Aircraft



PANEL CONTROL—At Republic Aviation, Farmingdale, NY, an R panel forms the top coordinating group, major members of which are shown. It forms policy, resolves interdepartmental problems, meets fortnightly. Heart of the operating system is the R Center, including 5 engineers, a mathematician, 2 statisticians and 4 analysts, plus 3 men in malfunction and accident analysis. This group prepares reports, assists in establishing R requirements, etc. There is also an R coordinating committee within the Engrg Dept which handles detailed engineering problems, with the aid of liaison men from QC, Field Service and Procurement.

the Reliability organization

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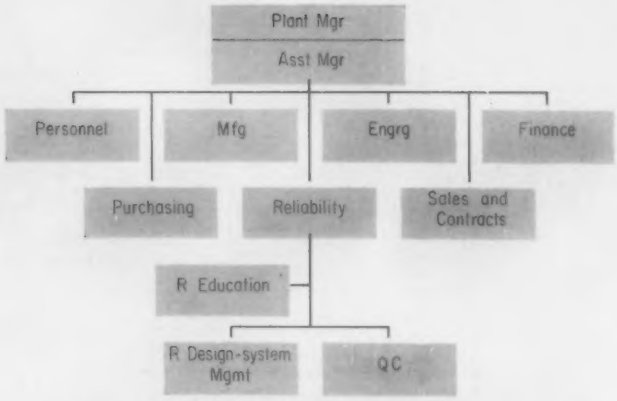
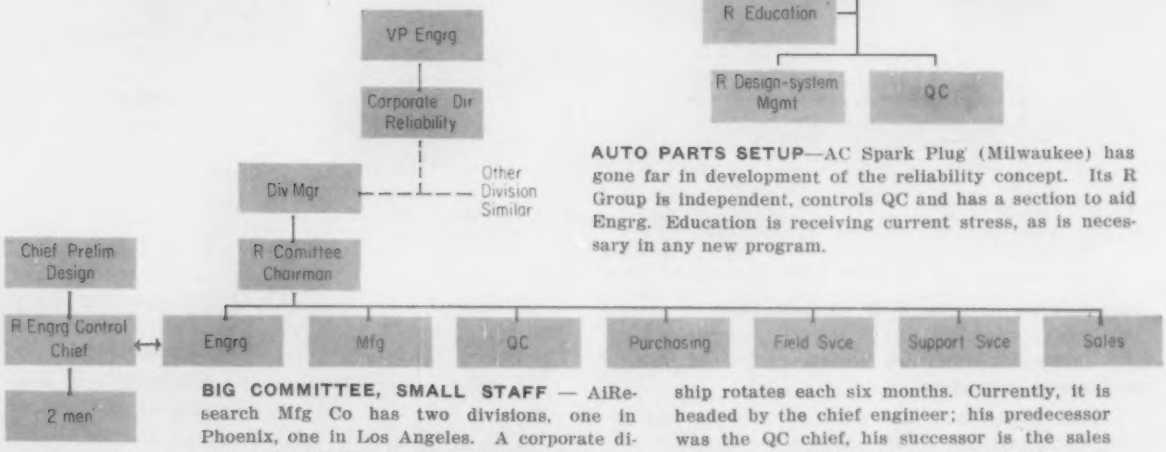


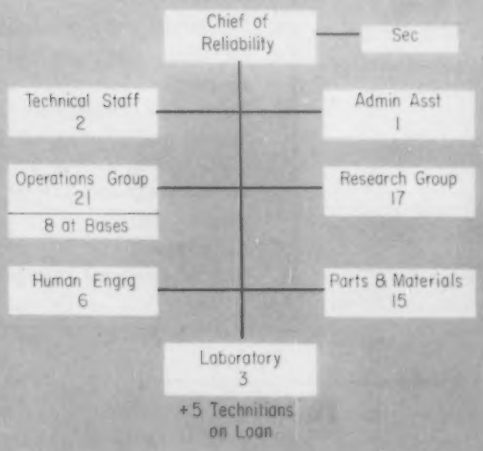
AUTO PARTS SETUP—AC Spark Plug (Milwaukee) has gone far in development of the reliability concept. Its R Group is independent, controls QC and has a section to aid Engrg. Education is receiving current stress, as is necessary in any new program.



BIG COMMITTEE, SMALL STAFF — AiResearch Mfg Co has two divisions, one in Phoenix, one in Los Angeles. A corporate director of reliability (an ME) coordinates policy, guidance and program, but actual responsibility is in a reliability committee that reports direct to each division manager. Committee chairmanship rotates each six months. Currently, it is headed by the chief engineer; his predecessor was the QC chief, his successor is the sales manager. The full-time reliability staff is small, consisting of three engineers from Engineering, the chief of which (PhD in applied math) is also Engineering representative of the committee.

POLICY COMMITTEE

Chief Engineer (Chmn)
Chief Tool Engineer
QC Manager
Asst Chief Engr—Design
Contracts Mgr
Factory Mgr
Asst Chief Engr—Devel
Product Office Mgr
Opers Office Mgr
Chief Project Engr
Material Office Mgr
Long-range Plan Mgr
Asst Chief Engr-Test
Asst Chief Engr-Admin
Chief of Reliability
(Division Manager is nominal chairman)



A DETAILED GROUP—75 full-time people form the Convair (Astronautics) Reliability Group. To give some idea of distribution and backgrounds, the numbers of people and their experience are shown. Note that 5 technicians from other depts are on lab loan; this number varies to suit needs and problems of preceding groups. Greatest experience is concentrated in the Parts & Materials group, most of whose members have at least 10 years of field experience. Lab is set up to X-ray photograph moving parts under vibration.

BACKGROUNDS OF R GROUP

Chief—EE major
Tech Staff—Physics
Operations—27 EE or ME
1 Tech Writer
1 Engrg Aide
Research—Head: Math & CE
2 Math PhDs
1 Master, Testing
10 Assts
2 Engrg Aides
2 Sec-clerks
Human Engrg—2 PhD
2 Engrg & Psych
2 Psychology
Parts & Mtrls—Head, 25 yrs experience
Specialists: seals, solid-state parts, materials, wiring & connectors. 8 are electronics engrs, 4 other engrs 1 aide, 1 sec-clerk
Laboratory—Head—ChE
Electronics Engr
X-ray Specialist-ME

implementing the program

H. F. Eppenstein, chief of reliability of Convair-Astronautics, has presented a detailed outline of his company's R program, subdividing it into four broad areas: research, operations, parts and materials reliability, and laboratory facilities. Each area has its own group within the R organization, broken down in turn by the functions listed here. It represents the best-integrated implementation we have thus far seen. Activities and functions are:

reliability research

1. Analytical methods. Originate approaches and perform researches leading to development of advanced mathematical and statistical method for measuring and predicting; calculate tolerances for and perform error analyses; apply most advanced mathematical and statistical methods to design and support of experiments; perform significant analyses and evaluations of search for critical-weakness testing and other data; originate and formulate suitable advanced training courses in reliability measurement methods, and conduct courses.

2. Human engineering. Consult and assist in design of control or monitoring displays; perform research and evaluations of man-machine relationships in equipment designs; review, study and analyze all levels of operations and procedures; develop reliability indoctrination and training programs.

3. Search-for-critical-weakness tests. Develop, schedule and implement search for such tests; perform research leading to extending usefulness of such tests in determining R factors; review, analyze and evaluate the results of such tests; direct the performance of statistical and mathematical evaluations of such test results; coordinate findings with other groups and functions as well as with other departments; recommend corrective actions on the basis of test results, and initiate corrective actions.

parts and materials reliability

1. Application and evaluation. Direct and coordinate specific applications research and evaluations on parts as well as on broad classes of engineering materials; assist design engineers by providing specialized technical support in parts and materials applications.

2. Liaison support and surveillance. Perform general factory parts and materials "use" liaison and surveillance, and maintain close liaison with Quality Control; review and analyze outgoing parts and materials documents; support AIA activities and perform as division AIA representative in parts and materials reliability.

3. Control functions. Originate or review and analyze for approval all requested standards for parts and materials requirements; review parts and materials requirements; review parts and materials specifications and tests; exercise design control of specific parts and materials applications; originate, publish and disseminate reliability-test requirements used by receiving inspection personnel in QC as the basis for accepting or rejecting incoming parts and materials.

reliability operations

1. Systems reliability. Review, study, analyze and prepare evaluations on equipment components, subsystems and systems for reliability improvement; recommend improvement actions and followup on such recommendations; review specifications and control drawings; perform consultative and surveillance activities in general production and field-use problem areas; provide chairmen for malfunction diagnosis teams in accordance with established procedures; initiate, plan and perform analyses and evaluations of systems interactions and implement corrective actions; initiate and/or perform and report on failure diagnoses, malfunction diagnoses, or failure analyses.

2. Field engineering. Maintain cognizance over the various R-program field activities, including those at test and operational bases; carry out followup on actions requested by Reliability Engineering personnel in the field and on actions to be taken by these personnel as directed by the organization; insure timely compliance on the part of Reliability Engineering personnel in the field with contractual requirements.

3. Data analysis. Initiate and implement methods for acquiring, interpreting, and processing into semipermanent records—including electronic accounting machine tabulations—failure, consumption, operational life, and other data classed generally as reliability data; perform research into and conduct regular analyses of methods, techniques, practices, and procedures for improving the effectiveness, accuracy and intelligibility of collected data, and how to present these data in various ways so as to be most effective as a corrective or informative feedback into the respective reliability programs; satisfy, in a timely manner, all contractual requirements.

reliability-laboratory facilities

Facilities provided in the human-engineering, diagnostic and special parts-testing laboratory areas supply test data to support much of the Reliability Engineering organization activity involving specialized laboratory effort. However, to avoid duplication, extensive use is made of other division testing facilities and of commercial-laboratory capabilities for extensive or large-scale testing.

1. Diagnostic laboratory. Diagnosis of failed parts and assemblies, determination of parts-failure modes, and special-parts evaluation techniques.

2. Special-parts evaluation laboratory. Special tests to establish reliability-test requirements for parts and materials in support of engineering and production activities on a division-wide basis; evaluation of new parts and materials to special requirements for improved reliability; statistical testing of parts and materials to provide data of the type needed for mathematical analyses.

3. Human-engineering laboratory. Design of reliability human-engineering test facility; evaluation of display-control parts and components; man-machine research on operational procedures and countdowns; research on "man into space" problems. ■

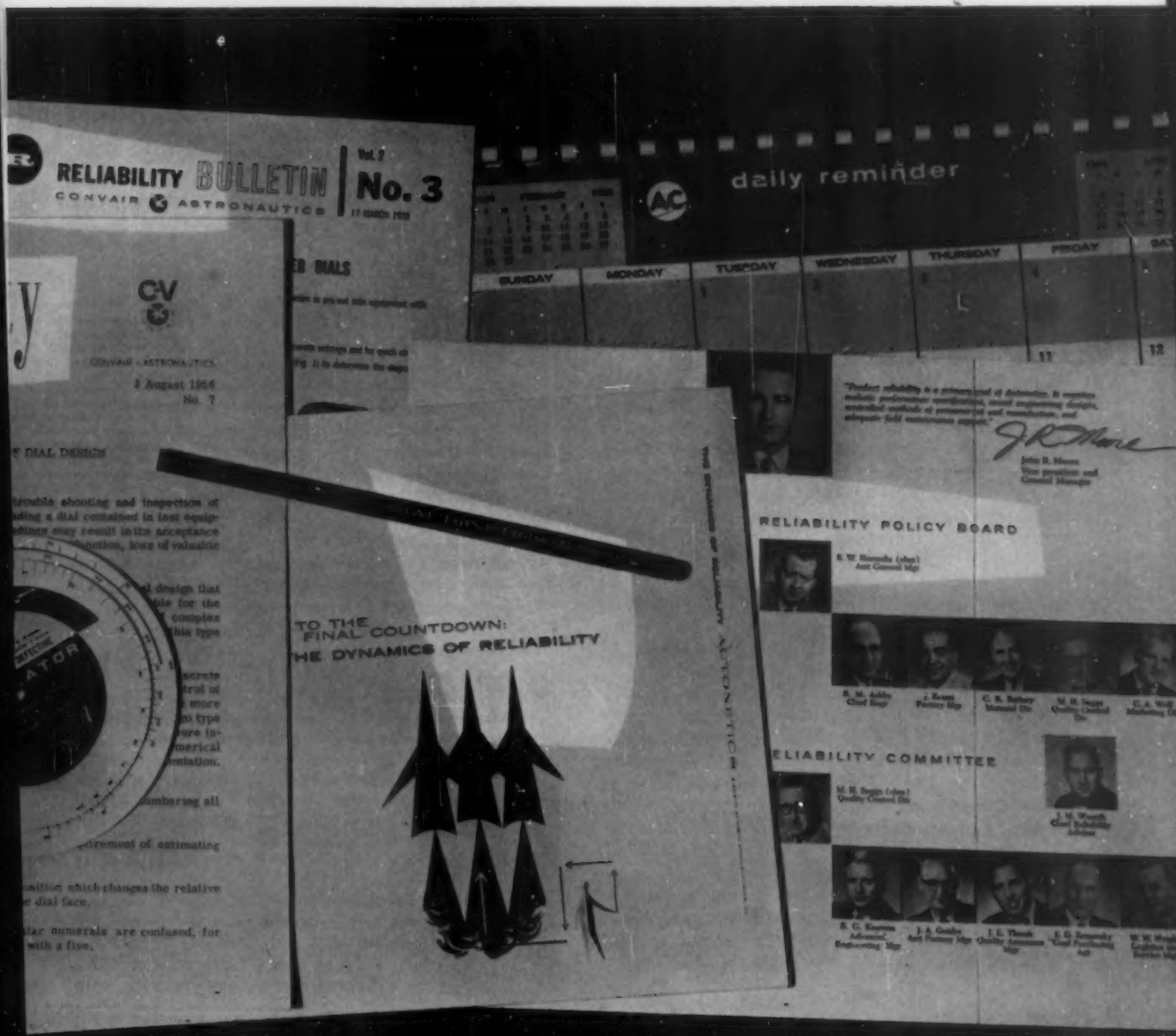
the importance of communications

"Reliability is the project engineer's problem." Reliability is "a number," "an attribute of the product," "a way of life." These are conflicting interpretations and definitions. They can lead promptly to chaos in any R program unless the third of the twelve basic principles

is remembered all the way through. In formal language, it borrows military terminology; it's called "personnel indoctrination." It's clearer in the old-time politico's "tell your story to the pee-u-pul."

Without exception, the successful R programs do just that, continually and constantly, and in a variety of ingenious ways. They have loose-leaf handbooks of reliability data for engineers, test crews, field men, periodic stories in company house organs, printed booklets showing the organization, memos and instruction sheets for handling all elements of the program.

But they go far beyond that. Some programs provide notebooks, note pads, match packets, calendars, pencils and even coffee coasters carrying reliability slogans. One company has a calculator to show the percentage of assemblies defective, another a postage-cancellation stamp. There are posters, brochures, movies, training manuals, technical bulletins. In the companies where these things are *all* done, the program has its greatest effectiveness.



responsibilities of a reliability group

A properly constituted reliability organization will have both in-line and advisory responsibilities. Some twelve basic ones are listed by Harry Powell, Technology Labs, for missile contractors and are here generalized.

1. *Environmental conditions determination* (Line). Review measurements of environment, interaction of product and environment; provide specifications and design data.
2. *Reliability apportionment* (Line). Apportion system R objective among components and objectives, disseminate objectives to design for evaluation and comparison, plan tests and pin-point problems.
3. *Reliability indoctrination* (Line). Explain and "sell" requirements and procedures to company personnel and vendors; institute a training program for engineers, technicians and management men.
4. *Parts-approval verification* (Line). Monitor engineering of components; review, coordinate and disseminate qualification test and performance data; maintain preferred parts lists, data files, vendor ratings and other data sources.
5. *Specification review* (Line and Advisory). Aid spec writers on questions of R objectives and statistical tolerances; review specs to see that R is not unduly compromised in trade-offs (i.e. with performance).
6. *Design review* (Line and Advisory). Aid designers in environmental problems, tolerances, component application, developmental marginal checking, effects of tooling on R, and human use factors; review designs for R factors such as safety margins, provision for preventive maintenance, and appropriate redundancy.
7. *Failure-reporting surveillance* (Line). Establish & maintain procedures for reporting all failures in plant or field; analyze individual failure reports and distribute to Production or Design for prompt correction.
8. *Statistical test planning* (Line and Advisory). Assist test engineers in planning best environmental and R tests, and in statistical design of experiments (sample size, stress level, test setup, etc.); review test plans.
9. *Statistical test evaluation* (Line). Analyze and evaluate all test reports to show product capabilities and weaknesses; explain data and results to designers; store and cross-index data and results.
10. *Quality-control coordination* (Advisory). Coordinate QC with R objectives, production-process control, and inspection tests designed to reveal incipient failures.
11. *Program data evaluation* (Advisory). Organize, analyze and evaluate all information and data on R, project estimates of achieved R to operational use, issue reports on problem areas and progress, maintain a list of critical assemblies and parts, work to "close the loop" by feedback of information or organization.
12. *Vendor control* (Line). Determine through proper tests and surveillance that supplied parts are adequate; test to demonstrate design capability, monitor vendor's QC and product-improvement program.

Reliability must be designed in

Reliability is still so new, particularly in mechanical applications, that relatively little published information is available. There are, however, many papers on electronic reliability and on such phases as the mathematics. Some companies (notably GE-Syracuse and Temco) have developed detailed training courses for internal use covering the math and testing phases; many have built up reliability manuals from all available data.

This report is at best a rapid survey of the field, an attempt to suggest a program, thus far largely concerned with missiles, that can be applied to any mechanical product. It offers a very real opportunity to the company producing a complex quality product and plagued by increasing current difficulties with performance.

We have offered an approach that combines engineering, production, and service, that suggests a working interrelationship based on engineering. It offers integrated methods for determining when, where and how much to test, how to equate reliability with cost, how to single out and correct the sources of trouble, how to predict with some confidence how well a product will perform.

It interrelates inspection, test and quality control, clarifies test procedures, even provides training and communication methods. It, in short, makes reliability a quantitative statistical concept instead of a vague promotional world. And it can save you money in the process.

The reliability program came about in the missile field because something had to be done to correlate time, performance and cost with today's high-production slapdash assembly. But other industries see in it the solution for some of their problems as well—those of in-warranty failures, worker indifference, customer irritation, user danger, and difficulties of maintenance. It may be the bridge between the unreality but reliability of a "one-hoss shay" on the one hand, and our current, mass-produced, but undependable products on the other.

Acknowledgments

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faster stress analysis of

COMBINED LOADS ON BEAMS

Though the author's method avoids use of differential equations, it gives comparable accuracy. It applies directly to simple beams and can be extended to beams with complex loads and statically indeterminate.

VICTOR KLEIN *supervisory mechanical engineer*
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Here is a faster way to find the stresses caused in a simple beam by combined axial and lateral loads. It avoids the time-consuming differential equations required by the conventional method. For example, most textbooks on strength of materials offer solution of this type of problem by using a differential equation such as

$$EI\frac{d^2F}{dX^2} = -N_x$$

Though the method given here requires less labor it retains a comparable degree of accuracy. The procedure is to use the ordinary equations for bending moment and deflection due to lateral loads only and, from them, derive equations and factors for bending moments and deflections due to combined loads.

The development here is for simple beams but the method for complex and statically indeterminate beams is analogous.

In practice, complex bending loads require individual analysis and summation. When they consist of a combination of loads, or when a complex lateral load is replaced by basic component loads, the total deflection and bending moment for a section can be found by the method of superposition—that is, by summarizing deflections and moments due to combination of each lateral component load with the given axial compression force.

BASIC EQUATIONS

In a simple beam of constant cross-section with and without axial compression forces (Fig 1 and 2; also see list of symbols, next page) the ratio of deflections is as follows:

$$\frac{F_X}{Y_X} = \mu = \frac{1}{1 - P_c/S}\text{; or } F_X = Y_X\,\mu = Y_X\frac{S}{S - P_c} \qquad (1)$$

The bending moment in section X, when axial compression forces exist, is:

$$N_X = M_X + P_cF_X = M_X + P_c\frac{S}{S - P_c}Y_X \qquad (2)$$

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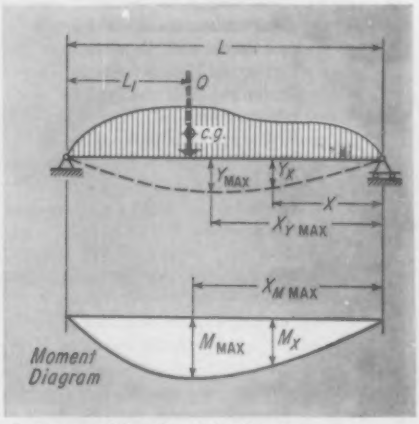
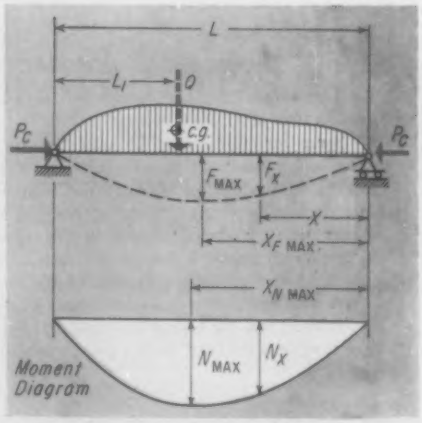
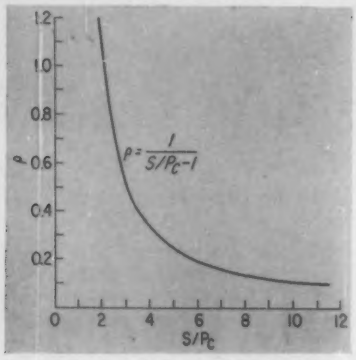


1 Beam with lateral load only



2 Beam with lateral and axial loads



3 Variation of factor with load ratio

SYMBOLS

- A — Area of beam cross-section, sq in.
- E — Modulus of elasticity, psi
- I — Moment of inertia, in.^{4}
- M — Bending moment due to lateral load only, in.-lb
- N — Bending moment due to combined lateral and axial loads, in.-lb
- P_L — $\Sigma Q + \Sigma W$, total lateral load, lb
- P_c — Axial compression forces, lb
- Q — Total continuous lateral load, lb
- q — Unit lateral load, lb per in.
- S — Theoretical Euler's force, lb
- W — Concentrated lateral load, lb
- X — Arbitrary section
- Z — Section modulus of beam, cu in.
- F — Deflection of beam due to combined lateral and axial loads, in.
- k — Numerical factor for a given section
- L — Span of beam, in.
- L_1 — Distance of loads from left support, in.
- Y — Deflection of beam due to lateral load only
- α — Numerical factor
- ψ — Functional factor of L and X
- μ — Functional factor of the ratio P_c/S
- ρ — Functional factor of the ratio S/P_c
- δ_b — Bending stress, psi (N_x/Z)
- δ_c — Compression stress, psi (P_c/A)
- δ_t — Total stress, psi $(\delta_b + \delta_c)$

HOW ABOUT ACCURACY?

The author's method speeds up stress analysis, but not at the expense of accuracy.

Some inaccuracy is to be expected, even with the conventional method of differential equations, because values for modulus of elasticity and moment of inertia are average, not exact. Also, in practice the beam is never perfectly hinged or fixed in the supports. There are always moments due to friction in hinges and elasticity of supporting members of the structure; and these moments can only be approximated.

Table II and Fig 6 show the close agreement between stress values calculated by the new and the conventional methods.

The formula for deflection Y_x, available from any engineering handbook, is:

$$Y_X = \frac{M_X L^2}{\alpha EI} \psi \tag{3}$$

Euler's theoretical force is given by:

$$S = \frac{\pi^2 EI}{L^2} \tag{4}$$

Substituting these values for Y_x and S into the equation for N_x:

$$N_X = M_X (1 + k_X \rho) \tag{5}$$

where

$$k_X = \frac{\pi^2}{\alpha} \psi \tag{6}$$

and

$$\rho = \frac{P_c}{S - P_c} = \frac{1}{S/P_c - 1} \tag{7}$$

Similarly, by substituting Y_x from Eq (3) into (1) gives:

$$F_X = \frac{M_X}{P_c} (k_X \rho) \tag{8}$$

Rewriting Eq (5) as

$$(k_X \rho) = \frac{N_X}{M_X} - 1,$$

and substituting into (8) gives:

$$F_X = \frac{N_X - M_X}{P_c} \tag{9}$$

The above equations show that calculation of N_x and F_x merely requires the determination of M_x and factors ρ and k_x. Here is a summary of the simplified procedure for the analysis:

1. Calculate M_x, using conventional formulas.
2. Calculate S, using Eq (4).
3. Calculate ratio S/P_c and obtain value for ρ from Fig 3, or Eq (7).
4. For the section X in question (ratio X/L), read in Fig 4 the value of k_x for the given loading (for convenience these values are also given in Table I). Key formulas with various lateral loads are tabulated on pages 100 and 101.
5. Calculate N_x and F_x from Eq (5), and (8) or (9).

Table II gives a comparison between the author's method and the conventional method for various values of the bending moments, N_x for the basic lateral loads. The ratio N_c/N_a indicates the degree of agreement between the two methods.

FINDING SECTION WITH MAX DEFLECTION

This method does not flect the influence of axial forces on the location of the section with maximum deflection—in other words, $F_{x\,max}$ cannot be determined directly. An approximate value can be obtained from the graph in Fig 5, which is calculated by the conventional method for lateral loading by a concentrated load and various ratios of S/P_c. Let us discuss the extreme values that $X_{Y\,max}$ and $X_{F\,max}$ can assume. For example, for symmetrical loading without axial forces, this section is in the middle of the span ($X_{Y\,max} = 0.50L$), and for the most unsymmetrical loading with the moment in one support

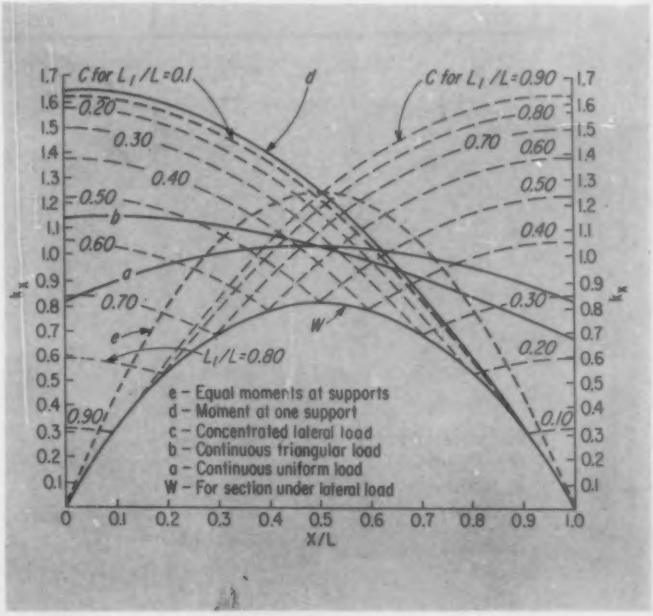
TABLE I—NUMERICAL VALUES FOR CURVES IN FIG 4

Type of Load	L_1/L	Location of ratio, X/L 0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
a		0.822	0.897	0.954	0.995	1.020	1.028	1.020	0.995	0.954	0.897	0.822
b		1.151	1.145	1.130	1.115	1.070	1.028	0.977	0.909	0.835	0.757	0.669
c	1.0	0	0.312	0.592	0.839	1.053	1.234	1.382	1.497	1.579	1.628	1.645
	0.9	0.312	**0.296**	0.576	0.822	1.036	1.217	1.365	1.480	1.563	1.612	1.628
	0.8	0.592	0.576	**0.526**	0.773	0.987	1.168	1.316	1.431	1.513	1.563	1.579
	0.7	0.839	0.822	0.773	**0.691**	0.905	1.086	1.234	1.349	1.431	1.480	1.497
	0.6	1.053	1.036	0.987	0.905	**0.790**	0.971	1.119	1.234	1.316	1.365	1.382
	0.5	1.234	1.217	1.168	1.086	0.971	**0.822**	971	1.086	1.168	1.217	1.234
	0.4	1.382	1.365	1.316	1.234	1.119	0.971	**0.790**	0.905	0.987	1.036	1.053
	0.3	1.497	1.480	1.431	1.349	1.234	1.086	0.905	**0.691**	0.773	0.822	0.839
	0.2	1.579	1.563	1.513	1.431	1.316	1.168	0.987	0.773	**0.526**	0.576	0.592
	0.1	1.628	1.612	1.563	1.480	1.365	1.217	1.036	0.822	0.576	**0.296**	0.312
d		1.645	1.628	1.579	1.497	1.382	1.234	1.053	0.839	0.592	0.312	0
e		0	0.444	0.790	1.036	1.184	1.234	1.184	1.036	0.790	**0.444**	0

a — continuous uniform load
b — continuous triangular load
c — concentrated load
d — moment in left support
e — equal moments at both supports
W — concentrated lateral load (values in bold face)

TABLE II—COMPARISON OF VALUES FOR MOMENTS N_x BY THE CONVENTIONAL (N_z) AND AUTHOR'S (N_x) METHODS

Loading	Location of loading L_1/L	Location of section X/L	Ratio N_x/N_z for $S/P_e = 2.0$ ($\rho = 1.0$)	Ratio N_x/N_z for $S/P_e = 6.0$ ($\rho = 0.2$)
Uniform	0.50	0.25	0.9987	0.9998
		0.50	1.0009	1.0001
		0.75	0.9987	0.9998
Triangular	0.33	0.25	1.0094	1.0011
		0.50	1.0009	1.0001
		0.75	0.9908	0.9992
Concentrated	0.50	0.25	1.0034	1.0004
		0.50	0.9969	0.9997
		0.75	1.0034	1.0004
	0.25	0.25	1.0316	1.0036
		0.50	1.0050	1.0004
		0.75	0.9795	0.9982
One moment	....	0.25	1.0426	1.0049
		0.50	1.0083	1.0010
		0.75	0.9701	0.9973



4 Variation of k_x with ratio X/L for various loading

$X_{Y\,MAX} = 0.577L$. When axial forces are added, the section with max deflection moves toward the middle of the span as P_e increases, and it is theoretically in the middle of the span when $P_e = S$ (for any lateral load). Thus max differential between these extremes is: $(0.577 - 0.500)\ L = 0.077L$ depending on the type of lateral loading and the ratio S/P_e.

COMPARISON OF METHODS

As an example of location of section with max N_z, consider a beam with concentrated load. Substituting value for N_z into (5) and differentiating gives:

$$N_X = M_X\,(1+k_X\,\rho) = W\,\frac{L_1}{L}\,X\left[1+\frac{\pi^2\,\rho}{6}\left(1-\frac{L_1^2}{L^2}-\frac{X^2}{L^2}\right)\right]$$

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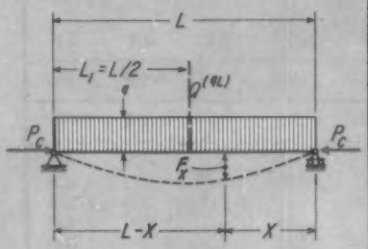
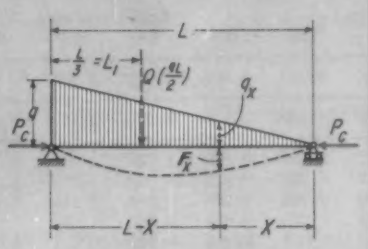
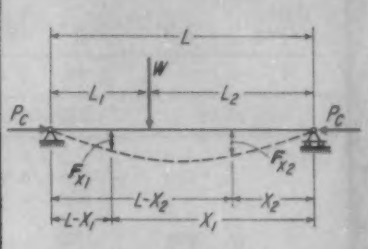
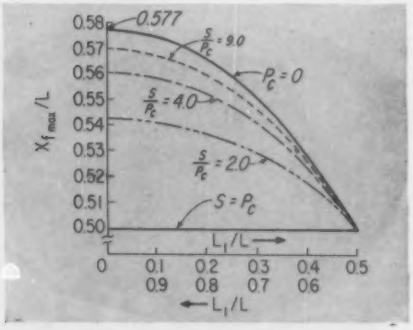
Key Formulas for Six Representative Loadings

Beam with axial and uniform lateral loads	Beam with axial and triangular lateral loads	Beam— axial and concentrated lateral loads
		
$Y_X = \frac{M_x L^2}{12\,EI}\left[1 + \frac{X}{L} - \frac{X^2}{L^2}\right]$	$Y_X = \frac{7M_x L^2}{60\,EI}\left[1 - \frac{3X^2}{7L^2}\right]$	$Y_{X(1)} = \frac{M_{X(1)}}{6\,EI} L^2\left[1 - \frac{L_2^2}{L^2} - \frac{(L-X)^2}{L^2}\right]$
		$Y_{X(2)} = \frac{M_{X(2)}}{6\,EI} L^2\left[1 - \frac{L_1^2}{L^2} - \frac{X^2}{L^2}\right]$
$M_X = Q\frac{X}{2L}(L - X)$	$M_X = Q\frac{X}{3}\left[1 - \frac{X^2}{L^2}\right]$	$M_{X(1)} = W\frac{L_2}{L}X \quad M_{X(2)} = W\frac{L_1}{L}X$
$k_X = \frac{\pi^2}{12}\left[1 + \frac{X}{L} - \frac{X^2}{L^2}\right]$	$k_X = \frac{7\pi^2}{60}\left[1 - \frac{3X^2}{7L^2}\right]$	$k_{X(1)} = \frac{\pi^2}{6}\left[1 - \frac{L_2^2}{L^2} - \frac{(L-X)^2}{L^2}\right]$
		$k_{X(2)} = \frac{\pi^2}{6}\left[1 - \frac{L_1^2}{L^2} - \frac{X^2}{L^2}\right]$



5 Variation of XF_{MAX} with L_1/L for various load ratios

$$\frac{d\,N_X}{d\,X} = 1 + \frac{\pi^2\,\rho}{6}\left(1 - \frac{L_1^2}{L^2} - \frac{3X^2}{L^2}\right) = 0$$

and

$$X_{N\,MAX} = \frac{L}{\sqrt{3}}\sqrt{1 + \frac{6}{\pi^2\,\rho} - \frac{L_1^2}{L^2}}$$

$$= 0.577\,L\sqrt{1 + \frac{0.608}{\rho} - \frac{L_1^2}{L^2}}$$

This equation indicates that for small values of ρ (when P_e is small) $X_{N\,MAX}$ is greater than L_2, and when $P_e = O$, then $\rho = 0$, and $X_{N\,MAX} = \infty$. This simply means that for small values of ρ the max bending moment is still under the concentrated load. The factor ρ will be a maximum when $X_{N\,MAX} = L_{(2)} = L - L_{(1)}$, which is in the center of the span. By putting $X_{N\,MAX} = L_2 = L - L_1$ into above equation, the value of ρ is determined at which the section $X_{N\,MAX}$ just starts to move toward the middle of the span. Simplifying the resulting equation gives:

$$\rho = \frac{1}{\frac{\pi^2}{3}\left(1\text{-}3\,\frac{L_1}{L} - 2\,\frac{L_1^2}{L^2}\right)}$$

and substituting

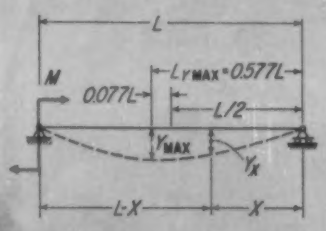
$$\rho = \frac{1}{\frac{S}{P_e} - 1}$$

gives

$$\frac{S}{P_e} = 1 + 3.29\left(1\text{-}3\,\frac{L_1}{L} + 2\,\frac{L_1^2}{L^2}\right)$$

This equation shows that for a value of $L_1/L = 0.25$, the ratio $S/P_e = 2.234$. By using a conventional solution with differential equations this value would be 2.250. This gives an indication of the accuracy that can be anticipated. Fig. 6 gives further indication how closely results of this method compare with those obtained by a conventional solution.

The elastic curve calculated by either method will show greater deflections in that half of the span where the total lateral load P_L is acting. Since the new method shows only the proportional increase of deflections, as indicated by Eq (1), this results in larger deflections than those obtained

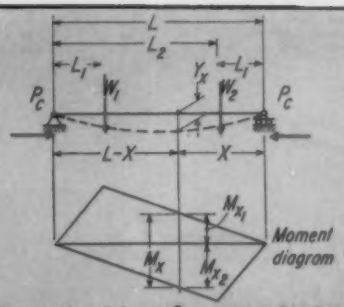


Beam with moment in one support only

$$Y_x = \frac{M_x L^2}{6EI}\left[1 - \frac{X^2}{L^2}\right]$$

$$M_x = M\frac{X}{L}$$

$$k_x = \frac{\pi^2}{6}\left[\frac{1 - X^2}{L^2}\right]$$



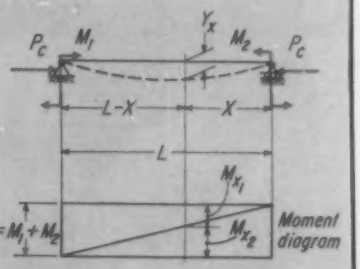
Beam with axial and 2 concentrated loads

$$F_x = \frac{M_x}{P_c}\ (k_x\rho)$$

or $$F_x = \frac{N_x - M_x}{P_c}$$

$$N_x = M_x\left\{1 + \frac{\pi^2\rho}{6}\left[\frac{3X(L - X) - L_1^2}{L^2}\right]\right.$$

$$k_x = \frac{\pi^2}{6}\left[\frac{3X(L - X) - L_1^2}{L^2}\right]$$



Beam with moment in both supports

$$F_x = \frac{M_x}{P_c}\ (k_x\rho)$$

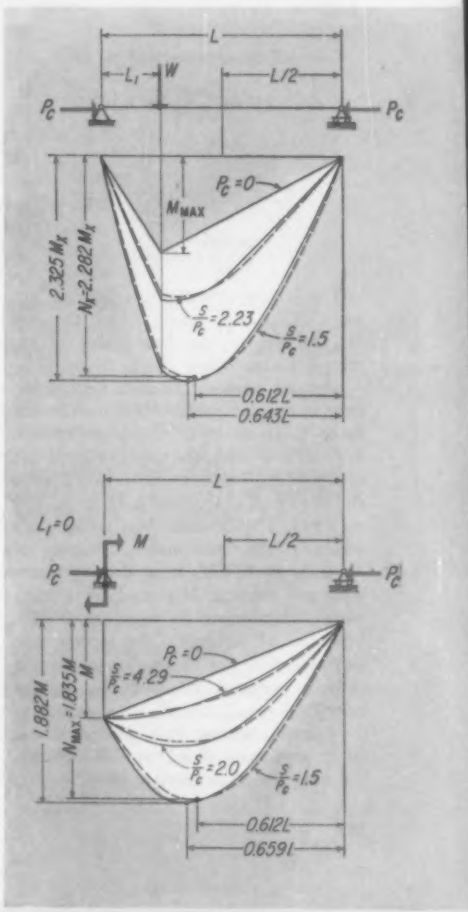
or $$F_x = \frac{N_x - M_x}{P_c}$$

$$N_x = M_x\left[1 + \frac{\pi^2\rho}{2}\frac{X(L - X)}{L^2}\right]$$

$$k_{x(a)} = \frac{\pi^2}{2}\left[\frac{X(L - X)}{L^2}\right]$$

by the conventional method in the half of the span where the total lateral load, P_L, is acting. This is clearly shown in Fig. 6.

The difference in the values of the bending moments calculated by the two methods is similar to the differences in the elastic curves described above. However, it is important to note that near the center of the span, which is usually the critical section, the values obtained by both methods practically coincide.



6 Moment diagrams compare author's method with conventional method (dotted lines).

EXAMPLE 1

An I-beam 6 by 4 in. and weighing 12.0 lb per ft, with $A = 3.53$ in.^{2}; $Z = 7.24$ in.^{3}; $I = 21.7$ in.^{4} and $E = 29 \times 10^6$ psi, is loaded as shown in Fig. 7. Determine total bending moment and stress in accordance with above procedure.

SOLUTION

1. To find total bending moment, compute moment due to concentrated lateral load, and from this subtract the bending moments due to moments at both supports.

$$M_x(W) = 1000\,\frac{65 \times 135}{200} = 43{,}850$$

$$M_x(1) = 12{,}000\,\frac{135}{200} = 8100$$

$$M_x(2) = 9{,}000\,\frac{65}{200} = 2920$$

$$M_x(L) = 43{,}850 - 8100 - 2920 = 32{,}830$$

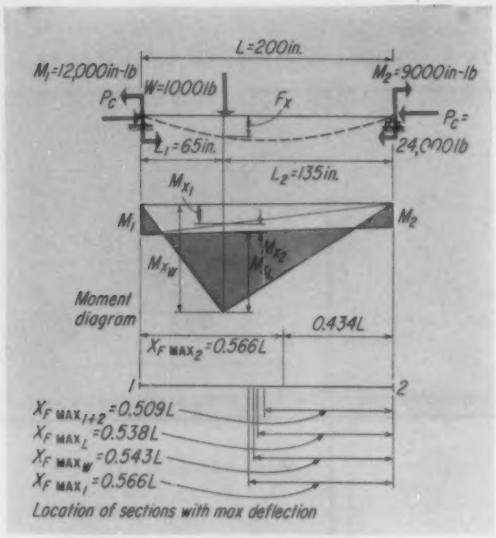
2. $$S = \frac{\pi^2 \times 29 \times 10^6 \times 21.7}{(200)^2} = 155{,}400$$

3. $$S/P_c = \frac{155{,}400}{24{,}000} = 6.48;\ \rho = 0.1825$$

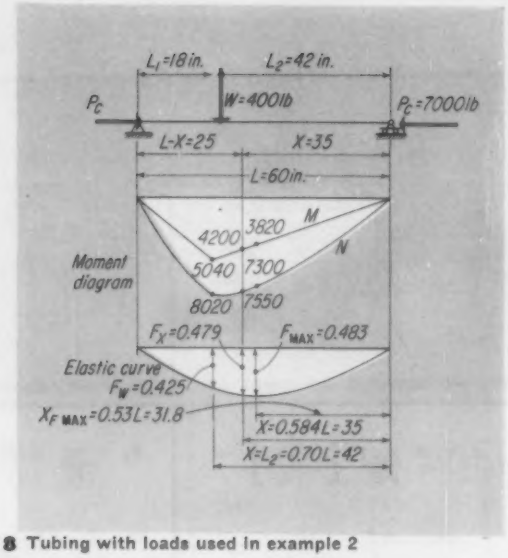
4. For the load W,

the ratio $$X/L = \frac{135}{200} = 0.675$$

The corresponding value of k_x from curve W (Fig 4) is: $k_{x(w)} = 0.721$. For the moment $M_{(a)}$, the value of $X/L = 0.675$, or the same as for load W, and $k_{x(a)} = 0.895$, taken from curve d, Fig 4. For the moment $M_{(a)}$, $X/L = 65/200 = 0.325$, where the distance X is taken from the support opposite to that loaded with



7 I-beam with loads used in example 1



8 Tubing with loads used in example 2

a moment. Using curve d in Fig 4, $k_{x(2)} = 1.472$.

5. The total moment here is the summation of the individual bending moments:

$$N_{X(L)} = M_{X(L)} + \rho\left[\sum_{i=1}^{i=n} (M_{x(i)} k_{x(i)})\right]$$

where i = a component load

In this case $N_{X(L)} = 32{,}830 + 0.1825\ (43{,}850 \times 0.721 - 8100 \times 0.895 - 2920 \times 1.472) = 32{,}830 + 3680 = 36{,}510$.

The deflection under load W is

$$F_X = \frac{3680}{24000} = 0.153$$

The total stress is

$$\delta_t = \frac{N_{x(L)}}{Z} + \frac{P_c}{A} = \frac{36{,}510}{7.24} + \frac{24{,}000}{3.53} = 10{,}840$$

The section with the max bending moment $N_{X(L)}$ will remain under the load W, because of the large value of the ratio $S/P_e = 6.48$.

The section with the max total deflection is interpolated as follows: The distance $X_{F\ MAX\ (W)} = 0.543$ for the ratio of $S/P_e = 6.48$ using the graph (Fig. 5) and interpolating between curves $S/P_e = 4$ and $S/P_e = 9$ at the ratio $L_1/L = 65/200 = 0.325$. The moment $M_{(2)}$ acting alone produces the maximum deflection at $X_{F\ MAX(2)} = 0.566L$ from the right support, and moment $M_{(1)}$ produces a maximum deflection at $X_{F\ MAX(1)} = 0.566L$ from the left support. The section with max deflection due to simultaneous action of both moments $M_{(2)}$ and $M_{(1)}$ will be between $X_{F\ MAX(2)}$ and $X_{F\ MAX(1)}$, nearer to the former, because it is greater. Using direct proportion based on the moments and their respective sections gives:

$$21\ X_{F\ MAX\ (1+2)} = (9 \times 0.434 + 12 \times 0.566) = 10.70\ L$$

$$X_{F\ MAX\ (1+2)} = \frac{10.70\ L}{21} = 0.509\ L$$

The section with the max deflection due to both the moments and the lateral load will then be found by similar interpolation between 0.509L and 0.543L, which is $X_{F\ MAX\ (L)} = 0.538L$.

EXAMPLE 2

A steel tube, with 0.065-in. wall thickness and 2.0-in. OD, is loaded as shown in Fig. 8. The cross-section values are: $A = 0.395$ in.^{2}; $Z = 0.185$ in.^{3}; $I = 0.185$ in.^{4}; $E = 30 \times 10^6$ psi. Determine bending moment N_X and deflection F_X in the section X at 35 in. from the left support.

SOLUTION

1. $M_X = 400\ \frac{18 \times 35}{60} = 4200$

2. $S = \frac{\pi^2\ 30 \times 10^6 \times 0.185}{(60)^2} = 15{,}200$

3. $S/P_e = \frac{15{,}200}{7{,}000} = 2.17$; $\rho = 0.855$

4. $\frac{X}{L} = \frac{35}{60} = 0.584$; $\frac{L_1}{L} = \frac{18}{60} = 0.30$; $k_X = 0.935$

5. $N_X = 4{,}200\ (1 + 0.935 \times 0.855) = 7550$

$$F_X = \frac{4200 \times 0.799}{7{,}000} = 0.479$$

The section with the max bending moment N_{MAX} is:

$$X_{N\ MAX} = 0.577\ (60)\ \sqrt{1 + \frac{0.608}{0.855} - (0.3)^2} = 44$$

The value of the ratio S/P_e at which the section with N_{MAX} starts to move toward the center of the span is

$$S/P_e = 1 + 3.29(1 - 3 \times 0.3 + 2 \times 0.3^2) = 1.93$$

The values of $X_{N\ MAX}$ and S/P_e show that maximum bending moment N_{MAX} that maximum bending moment N_{MAX} is still under the load W. Here M_{MAX} is:

$$M_{MAX} = 400\ \frac{18 \times 42}{60} = 5040$$

From curve W in Fig 4, at the ratio $X/L = 42/60 = 0.70$, $k_W = 0.691$. Using this for max combined moment gives:

$$N_{MAX} = 5040\ (1 + 0.691 \times 0.855) = 8020$$

$$F_W = \frac{5040 \times 0.59}{7000} = 0.425$$

$$\delta_t = \frac{8020}{0.185} + \frac{7000}{0.395} = 61{,}000$$

The section with the max deflection F_{MAX} is determined by interpolating values $S/P_e = 2.17$ and $L_1/L = 0.3$ in Fig. 5 giving $X_{F\ MAX}\ L = 0.53$; or $X_{F\ MAX} = 0.53 \times 60 = 31.8$. The bending moment in the section with max deflection is:

$$M_{F\ MAX} = 400\ \frac{18 \times 31.8}{60} = 3820$$

Again, from Fig 4 for $X/L = 0.53$ and $L_1/L = 0.3$ $k_X = 1.034$.

This permits calculation of combined bending moment at section with max deflection, as well as the max deflection:

$$N_{F\ MAX} = 3820\ (1 + 1.034 \times 0.855) = 7300$$

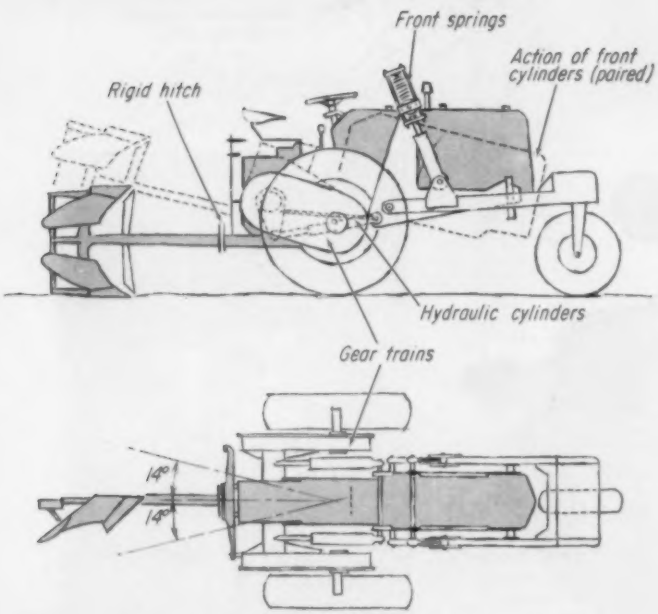
$$F_{MAX} = \frac{3820 \times 0.885}{7000} = 0.483$$

With the above values for F, M and N the elastic curve and moment diagram can be constructed as shown in Fig. 8.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St., New York 36, NY.

Tractor Floats on Hydraulic Jacks

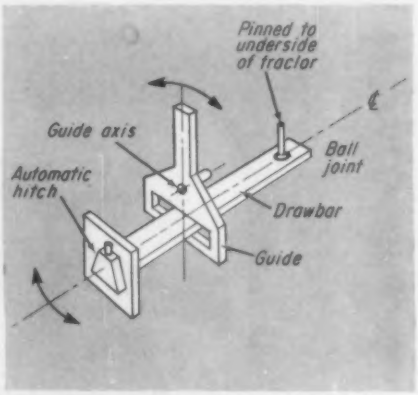
Its articulated wheels are positioned by double-acting hydraulic cylinders. These, plus swiveling tool-hitch, allow tractor to stay vertical regardless of slope. Variable elevation of rear end controls tool depth.



WHEEL POSITION is altered in respect to tractor frame by four hydraulic cylinders. Result is the engine and operator can stay level regardless of land slope.

Articulated bracket near center of frame carries the front wheel. Two cylinders attached to the bracket work together to control fore-and-aft position or pitch angle. These cylinders float while the tractor is working and, combined with integral springs, act as suspension for the tractor. Rear cylinders control operating depth of the tools rigidly attached to rear of tractor.

Rear wheels swivel on housings of the gear trains that drive them. Hydraulic cylinder on each rear wheel operates independently to change wheel height. The ground-clearance range is from 95 to 575 mm (3.7 to 22.6 in.) Individual wheel control permits tractor to tilt to either side and remain vertical while working across the face of a slope.



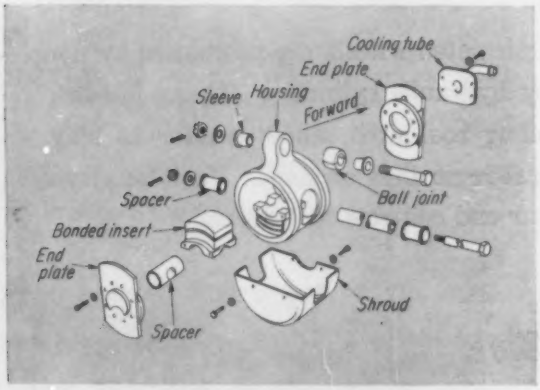
SWIVELING DRAWBAR controls the tools at set working depth but permits yawing movements. This prevents tool oscillation from being transmitted to single front wheel, and simplifies steering. Drawbar passes through a guide pivoted to rear of the frame and is connected to tractor by a ball-and-socket joint. Yawing movements of the tool are limited to 14° swing on either side of the centerline. Pivoted guide rotates to keep tool perpendicular to the surface of the ground.

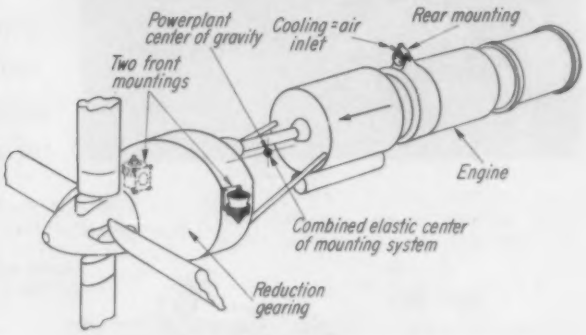
PS . . . Floating tractor is powered by 25-hp diesel engine. Ability to work steep slopes permits machine cultivation of areas normally limited to grazing. Jacks are controlled by valves in 100 kg/cm² (1422 psi) hydraulic system. Tractor is produced by Ets. de Jouette Toulon (Var), France.

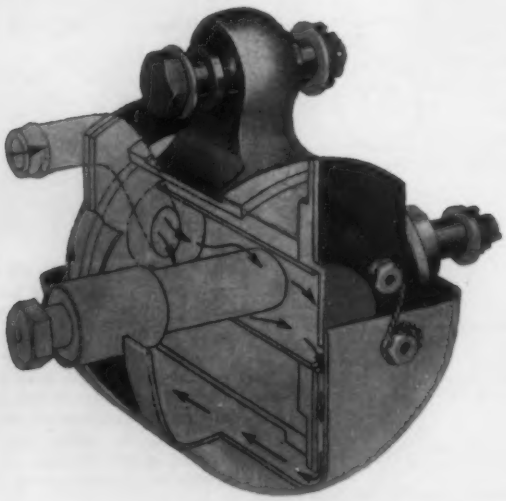
Forced Air Cools the Engine Mount

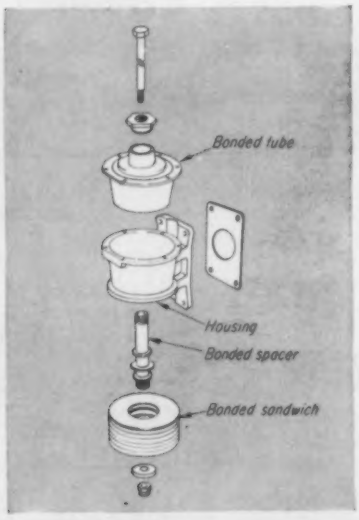
Ram air, bled from cooling ducts, permits use of elastomer shock mounts in 600-F atmosphere. Flexible, three-point suspension system isolates engine and propeller vibrations, weighs only 25 lbs.

TWO FORWARD MOUNTS carry vertical, lateral and longitudinal loads. The single rear mount carries vertical loads and acts as a 2-dimensional link to accommodate fore-and-aft thermal expansion, and minimize lateral loads. Rear mount also resists pitching movements produced by gyroscopic action of propeller and compressor turbine.







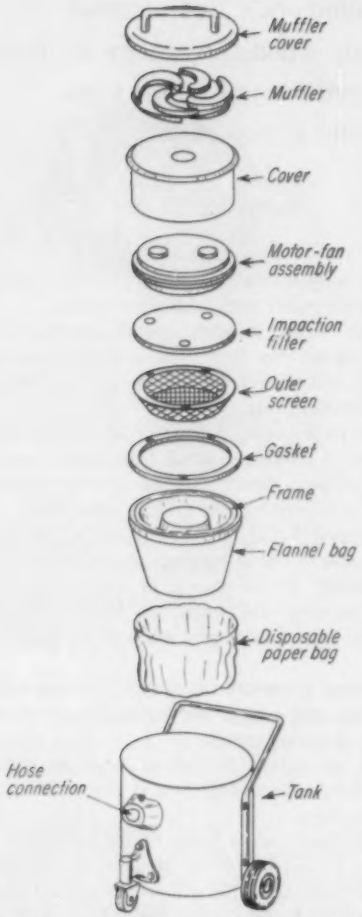


PS . . . Weighing just 25 lb, the suspension system carries entire weight, torque and thrust of the Allison 501-D13 turboprop engine used by Lockheed "Electra." Propeller rotating at 1020 rpm produces low-frequency vibration, while compressor and turbine turn at 13,820 rpm, producing a high-frequency vibration. These vibrations cannot cause structural damage and passenger discomfort; they are isolated from airframe by "Dynafocal" suspension system, developed and produced by Lord Mfg. Co, Erie, Penna.

AIRCOOLED REAR MOUNT is attached to engine at a point where skin temperature reaches 600 F. When the aircraft is in flight, ram air is bled to this mount from same ducts that cool the generator. On the ground, heat damage is prevented by the aluminum shroud which covers the rubber portion of the mount. The shroud is polished and anodized a bright silver to provide maximum heat rejection. Air from ducts flows in through a tube at the rear of the mount, around the rubber inserts, and is deflected upward by the shroud.

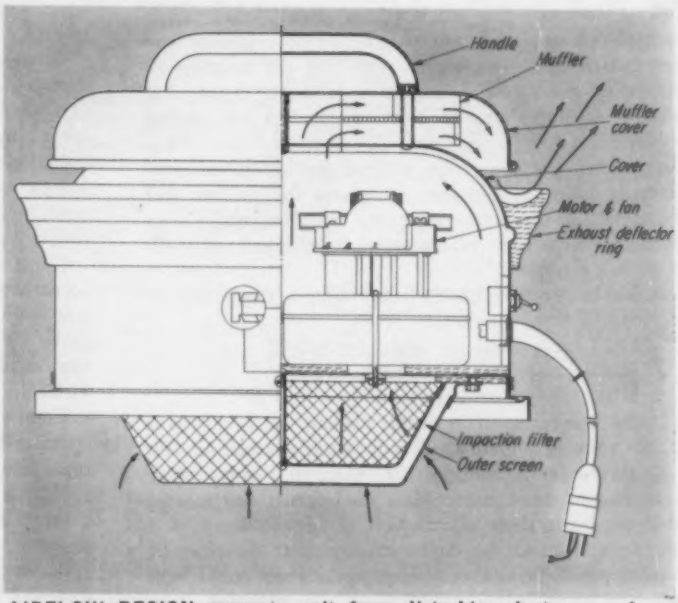
Triple Filtration Eliminates Dust

This vacuum cleaner protects sterile surroundings by trapping particles as small as 0.3 microns. Controlled exhaust flow reduces turbulence, does not raise additional dust.



IMPACTION FILTER, sandwiched between wire mesh, traps any particles that pass first two filters in vacuum tank. Porous filters in collection tank combine a disposable paper bag with a reuseable flannel collection bag. Cleaner consists of wheeled collection tank to which the vacuum head is clamped. Neoprene gasket on upper edge of tank is compressed by clamps to seal joint.

For wet pickup, a cyclonic separator with wet shutoff replaces the flannel filter and paper bag. Pickup tank is lined with an epoxy resin to resist corrosive effects of germicidal detergents.



AIRFLOW DESIGN prevents unit from disturbing dust on uncleaned portions of floor. Deflector diverts exhaust upward at 30° above the horizontal; increased exhaust-port area reduces air velocities. Air from the first two filters is pulled through the impaction filter, forced through the felt muffler, and directed upward by the exhaust deflector ring.

PS . . . Developed to reduce contamination in mechanically and medically sterile areas, the cleaner can be used for both wet or dry pickup; is more than 99% efficient when trapping 0.3-micron particles. Two ½-hp motor-fan units pull 145 cfm to produce a 42-in. water lift at end of a 10-ft hose with 5/8-in. orifice. Capacity of collection tank is 2/3 bushel of dry material or 5 gal. of liquid: "Microstat" vacuum cleaner is produced by Kent Co, Rome, NY.

SELECTING COUNTERS for DIGITAL DISPLAY

The human is inferior to a counter when converting analog (meter) data to unambiguous numbers. But counters present problems too—particularly when the energy available is limited. Here are specific suggestions on counter type, speed, driving torque and life—and a case history.

PETER B TROUP, *manager*
Indicator & Electronics Design Unit
Instrument Dept
General Electric Co, West Lynn, Mass

Most displayed data originates in analog form, and is then shown in analog form by means of a pointer and scale. After this the operator performs the function of converting the analog presentation to digital form. But because of limitations of this human link the analog display tends to be ambiguous. Counters are better. They can perform the conversion without ambiguity, provided adequate power is available to operate the counter and the signals do not fluctuate too rapidly. However, such a digital display is more expensive, more complex, and tends to be less reliable.

Before deciding to convert from analog to digital display ask yourself three questions:

1. Do I really need the high readability?
2. Can I justify the added cost?
3. If the signal fluctuates, how do I read it?

If the answers point to digital readout the next step is to select the best method of conversion, recognizing that a digital display is nothing more than an analog display performed in small steps. Most instruments and sensing devices present their information as the positions of a rotating shaft, and the digital display must therefore be coupled positively to this shaft—a code wheel could light indicator lamps behind numbers on a translucent plate. But this is seldom a practical answer because of size, weight and cost. Ambient light of high intensity would also present a problem. A more practical approach uses a mechanical counter, but selection of the best type can also be a problem.

Two different methods are employed in indexing the counter wheels: internal pinion and external pinion. Internal-pinion construction is inexpensive and takes less space (axially); major disadvantages are slow speed (100 to 200 rpm max) and high operating torque (0.2 to 0.5 in.-oz). Also, final assembly of the parts inside the wheel must be done blind.

External-pinion counters require space between wheels for the pinions, but can be operated at 1000 rpm or more, with driving torque no more than 0.05 in.-oz. Reset to zero can be incorporated with additional parts.

Wheels can be supplied with special graduations; shutters can be added to cover the reading opening at a specific count; belts driven by the wheels can display special number combinations.

Major problems in selecting a counter arise when the application requires a combination of high speed, quick response and low torque. Power required becomes a controlling factor in the capacity of the driving signal or servo.

Contrary to general belief, maximum driving torque occurs when only one wheel is turning; minimum torque when all are turning. Major source of friction is the rubbing between moving and stationary wheels. Variatons in torque arise from flashes and whiskers on rubbing surfaces.

Transfer of a count generates forces that increase with speed; nylon pinions and wheels are essential to cushion this shock at high operating speeds.

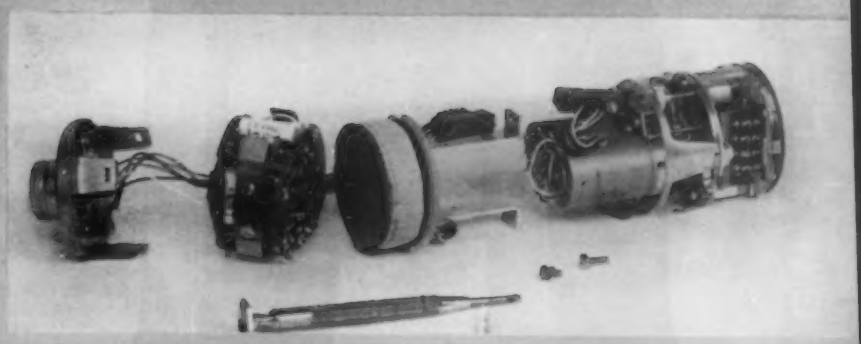
Where counters are driven by helical or worm gears, a thrust bearing should be added—two if the counter is driven in both directions.

Because counter wheels are a loose fit on the shaft, a thin dished washer should be placed between the slowest wheel and the shaft bearing. This will set up a small end-thrust on all wheels and add vertical stability as well as take care of differential expansion at temperature extremes.

HOW TO SPECIFY A COUNTER

Capacity. Display no more digits than necessary. Unnecessary digits increase chances for failure. More digits that are required for the desired resolution introduce higher operating speeds and decrease the life

Readibility. Wheels ¾ in. dia with numerals $\frac{7}{16}$ in. high can be read at distances 18 to 24 in.; 1-in. wheels with ½-in. numerals, 3 to 4 ft. A ½-in. wheel is sometimes used when space is limited, but readability is poor.



DEVELOPMENT OF A LOW-FRICTION COUNTER turned out to be a major problem in designing a servo indicator for our aircraft fuel flowmeter. We wanted a counter, instead of a pointer and scale, to give a more precise indication—one that would not be subject to error in reading.

FOUR-DIGIT CAPACITY was needed to give the desired precision.

SPACE LIMITATIONS plus inherently close reading distances led to the selection of ½-in.-dia counter wheels. Internal lighting was added to provide good readability under conditions of low ambient illumination. White figures on black background gave best readability under these lighting conditions.

OPERATING SPEED had to be 1000 rpm to meet the response time specified, and this called for an external-pinion counter.

TORQUE REQUIRED by the counter proved to be the major problem faced, which led to the development of a low-torque design requiring only 5 to 10% of the power needed by a conventional counter. Torque demand directly influenced the output, size and heat dissipation of the servo amplifier that supplies power to the servomotor driving the counter, and therefore became the primary design problem.

Conventional counters were found to require an amplifier of at least 2 or 3 watts output, and even this was not sufficient at temperature extremes. The space required for such an amplifier was impractical, and the temperature rise introduced problems of dissipation and derating that made the cost prohibitive. We had to reduce the power required to drive the counter.

To bring the amplifier volume down to the space available we needed a counter with a max operating torque of 0.01 in.-oz at room temperature, and not more than 0.10 in.-oz at —55 or +100 C. We met these requirements finally by specifying:

WHEELS—nylon, cleaned and free of flashes and whiskers, and adjusted to a loose fit on the shaft.

PINIONS—cleaned and adjusted for smooth operation on the shaft.

BEARINGS—longer, with a flange on the drive-end bearing to take thrust from the right-angle drive.

ENDPLAY—spring washer added between slowest wheel and frame to give light thrust for vertical stability, and to allow for thermal expansion.

Black figures on a white background are generally more readable than white figures on black background. If a black background is used it should be a dull or matte finish.

Operating Speed. Below 200 rpm either an internal or external pinion type can be used; over 200 rpm, only the external type. For speeds over 400 or 500 rpm, specify nylon instead of metal wheels. Higher speeds are permissable with smaller wheels. Life of a counter falls off rapidly with increasing speed, approximately in a logarithmic relation.

Torque. Best commercial external-pinion counters have a breakaway torque of 0.01 in.-oz at room temperature; at —65 or +200 F the torque increases to about 0.1 in.-oz. For internal-pinion counters the values are about 10 times larger.

When measuring torque the load must be increased smoothly to the breakaway point; hanging weights of increasing value on a torque arm will not give accurate results.

Reset. Special forms of internal-pinion counters can be reset to zero by driving the counter in reverse for one or two revolutions. This design has added complexity, increased possibility of failure, and higher forward operating torque.

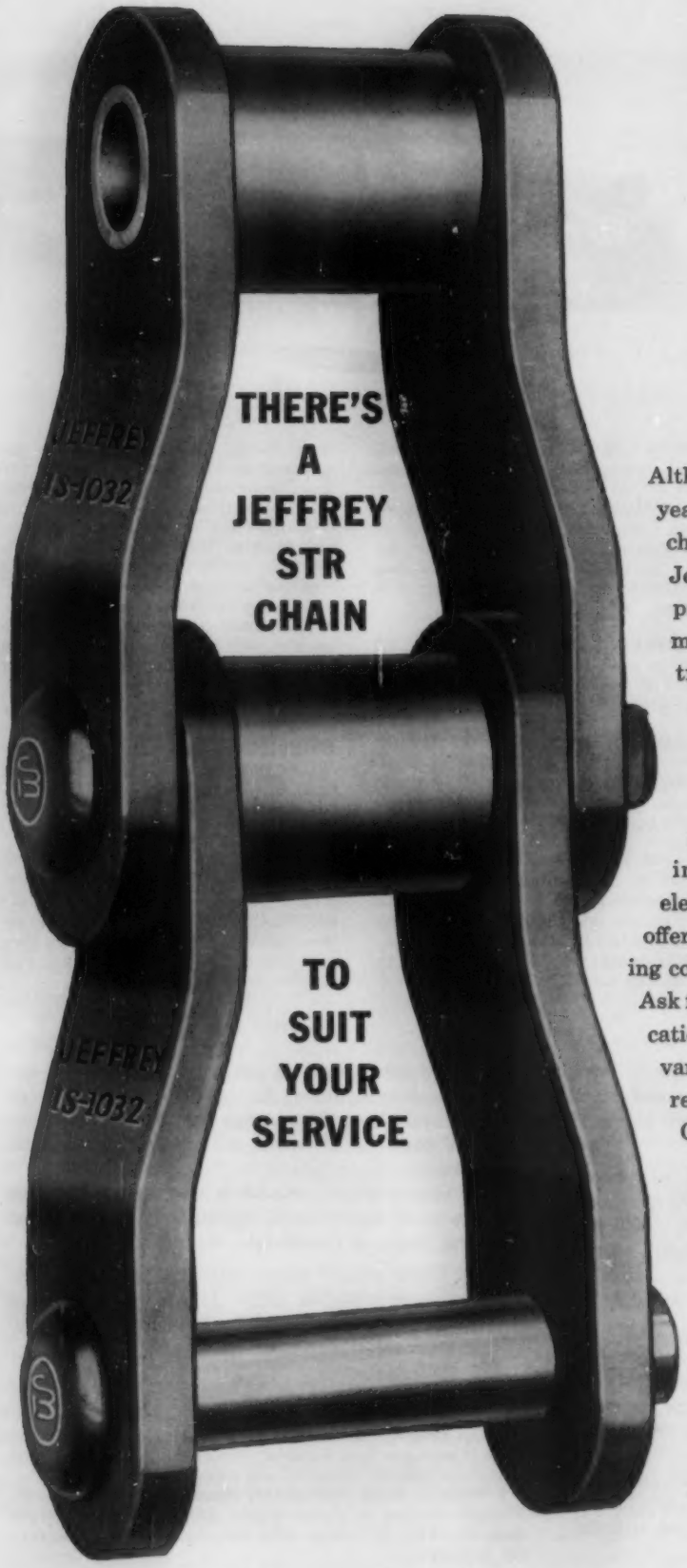
The external-pinion counter is reset by heart-shaped cams, manually or electrically operated. It does not affect operating torque or counter life.

Life. While counter design influences life, the application is a more important factor. Life is usually specified in terms of a cycle consisting of a full-range up-scale and down-scale count at a specified speed.

EDITOR'S NOTE: Two earlier articles include specific recommendations on readability of scales and digits:

Three Criteria for Readable Panel Markings, May 25 '59, p 55. Discusses best lettering for visibility and for rapid scanning; also for counters and legend lights.

9 Ways to Make Instruments Readable, Feb 3 '58, p 61. Though directed to analog scales, this article does include data on effect of height-width ratio and reading distance for numerals.



Although Jeffrey patented the principle years ago, STR (Steel Thimble Roller) chain has been constantly improved by Jeffrey to keep pace with industrial progress. Components are designed, materials selected, machined and heat treated to give maximum strength, shock resistance and wearability with minimum weight.

Jeffrey STR chain provides a positive yet flexible means of transmitting power for unit machinery and general industrial drives, and for heavy duty elevating and conveying service. Jeffrey offers four classes to meet various operating conditions.

Ask for engineering assistance on the application of STR chain to suit your needs. The various classes of STR chain are in stock, ready for immediate shipment to you. Chain also can be tailor-made to fit your particular requirements. The Jeffrey Manufacturing Company, 788 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...
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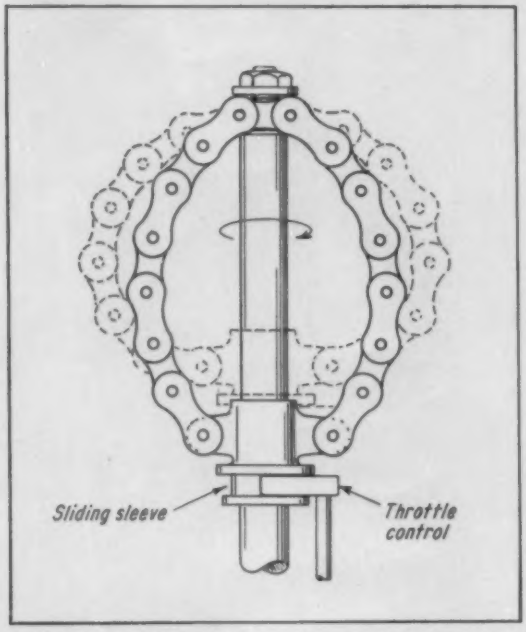
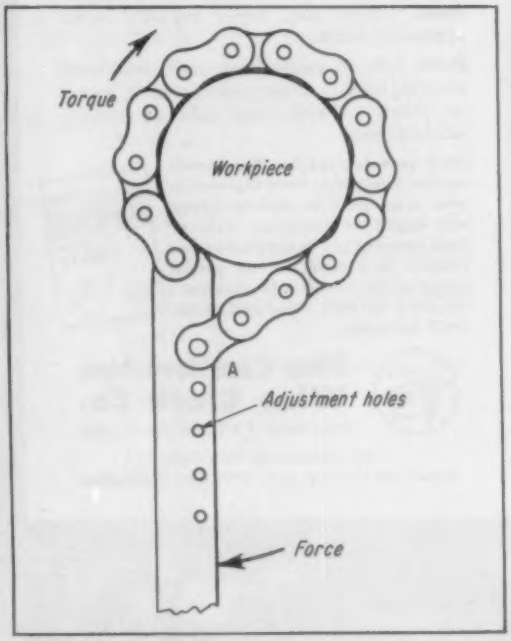
6 MORE JOBS for ROLLER CHAIN

Some further examples of how this low-cost but precision-made product can be arranged to do tasks other than transmit power. Other examples were given in the May 2 issue.

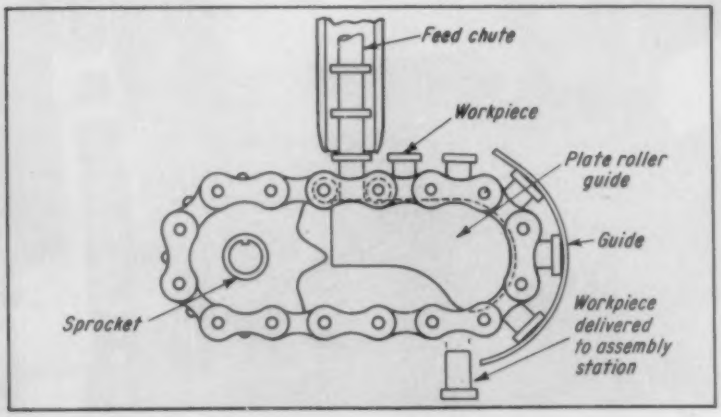
PETER C NOY, *manufacturing engineer*
Canadian General Electric Co Ltd, Barrie, Ont



1 SIMPLE GOVERNOR—weights can be attached by means of standard brackets to increase response force when rotation speed is slow.



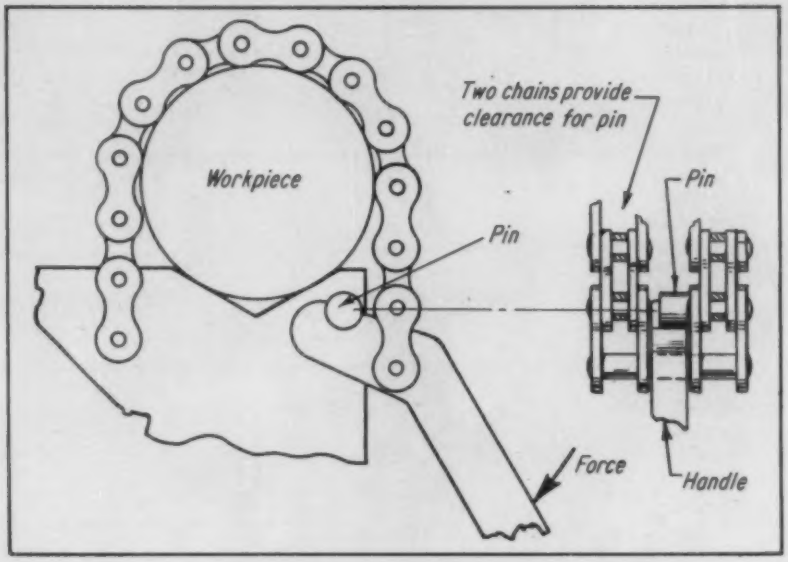
2 WRENCH—pivot **A** can be adjusted to grip a variety of regularly or irregularly shaped objects.



3 SMALL PARTS CAN BE CONVEYED, fed, or oriented between spaces of roller chain.

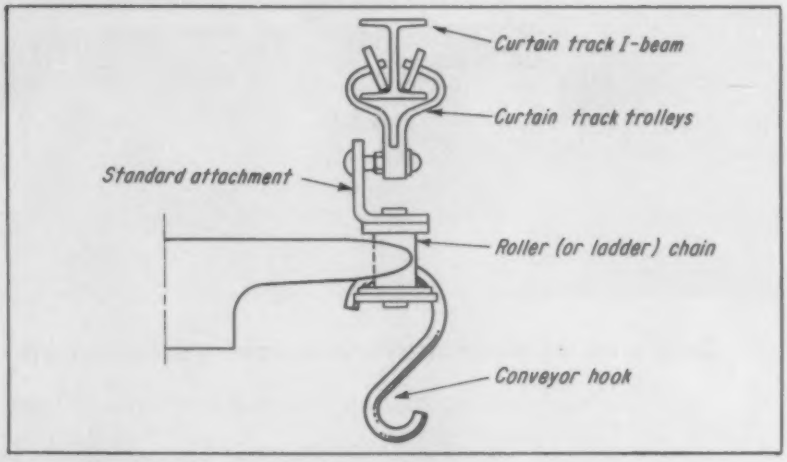
continued on page 111

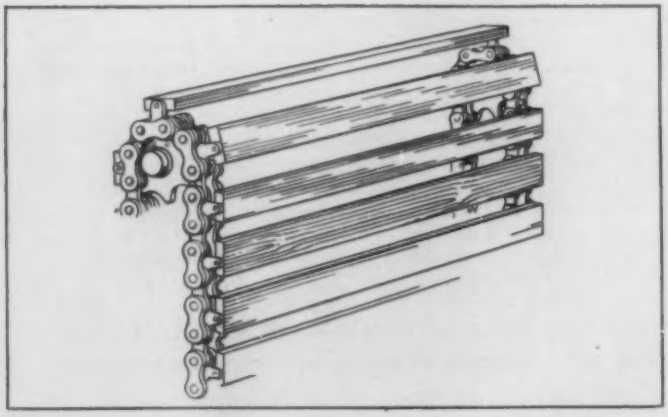
. . . FAST, UNIFORM PROCESSING — 1965 . . .
CAMBRIDGE METAL-MESH BELTS are the answer to the big problems you'll face in the competitive 60's—tighter operating costs, higher production and consistent quality.
Continuous movement of foods, metal parts, ceramics or chemicals on Cambridge Belts through processing operations speeds production and eliminates costly manual handling. Open mesh construction allows heat, cold or liquids to flow through the belt and around the product for thorough, uniform treatment. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs.
Belts can be made heatproof, coldproof or acidproof — in any mesh, weave, metal or alloy — with any side or surface attachments.
Have your Engineering Department call the Cambridge Field Engineer in your area. He'll be glad to discuss any aspect of Cambridge Belts — from manufacture to installation and service. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.
Cambridge
CONVEYOR
BELTS
The Cambridge Wire Cloth Co.
Department P • Cambridge 5, Md.
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications



4 CLAMP—toggle action is supplied by two chains, thus clearing pin at fulcrum.

5 LIGHT-DUTY TROLLEY CONVEYORS can be made by combining standard roller-chain components with standard curtain-track components. Small gearmotors are used to drive the conveyor.





6 SLATTED BELT, made by attaching wood, plastic or metal slats, can serve as adjustable safety guard, conveyor belt, fast-acting security-wicket window.

Only one of sixty materials met these tough filter specifications

Troyfelt, a non-woven synthetic Dacron, gave best performance in military vehicle engine.

The specifications? Ability to produce nearly 100% filtering efficiency in heavy dust conditions, in temperatures from -65 to 275°F, resistance to oil, moisture, rot and mildew. The product? The filter on a heavy duty engine intake air cleaner on a military vehicle. The result? Out of sixty materials tested, only one, TROYFELT, did the job.

The secret behind TROYFELT'S success is its specialized manufacturing process of mechanically interlocking the Dacron, Orlon and other special synthetic fibers rather than chemically binding them or introducing binder fibers. This method eliminates the old filter "bugaboo" of blinding caused by such binders or binding agents and gives TROYFELT its unusually high, long-lived strength, excellent resistance to fungi and bacterial growth, chemicals, moisture, oil, abrasion, stability to temperature extremes and many others.

But, filtering is only part of the TROYFELT story — other applications for this remarkable material include insulators, seals, padding, packings, gaskets and many others. We'll be glad to send you our bulletin describing most of them and samples.

TROYFELT ... *by the pioneers in non-woven synthetic felts*

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PRODUCT ENGINEERING

1960 DESIGN ENGINEERING SHOW

ASME CONFERENCE

Program, session by session . . . p 114; Who's who and What's what . . . p 116.

Floor plan . . . p 134; Who's showing what . . . by exhibitor p 136, by product p 154; New products on display . . . p 174; New catalogs and bulletins . . . 225.

ASME DESIGN ENGINEERING

NEW YORK COLISEUM

May 23 . . . Monday

9:45 AM . . . NEW HORIZONS IN ENGINEERING DESIGN . . . SESSION I

CO-CHAIRMEN:
DR HUGH L. DRYDEN, Deputy Administrator, National Aeronautics and Space Administration, Washington, DC.
DR ARTHUR R. KANTROWITZ, Director, Avco-Everett Research Laboratory, Avco Corporation, Everett, Mass.

PANEL MEMBERS:
WILLIAM R. GALL, Chief of Design Section, Reactor Experimental Engineering Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.
VARICK D. SCHWARTZ, Assistant Project Manager, Army Boiling Water Reactor Project, Combustion Engineering Inc, Windsor, Conn.
GEORGE P. SUTTON, Chief Scientist, Advanced Research Projects Agency, Department of Defense, Washington, DC.
ELMER P. WHEATON, Vice President-Engineering, Missiles and Space Systems, Douglas Aircraft Company Inc, Santa Monica, Calif.

May 24 . . . Tuesday

9:30 AM . . . RELIABILITY . . . SESSION II

CO-CHAIRMEN:
FRANK McGINNIS, Director, Reliability and Quality Control, Sperry Gyroscope Company, a div of Sperry Rand, Great Neck, NY.
NICHOLAS OSIFCHIN, Military Development Engineer, Bell Telephone Laboratories Inc, Whippany, NJ.

60-MD-1: **Reliability Prediction—Its Validity and Application as a Design Tool**
THOMAS C. REEVES, Director of Product Assurance, RCA Defense Electronic Products Division, New York, NY.

60-MD-2: **Impact of Reliability on Design**
HARRY R. POWELL, Member of Senior Staff, Space Technology Laboratories Inc, Los Angeles, Calif.

9:30 AM . . . FABRICATION . . . SESSION III

CO-CHAIRMEN:
HEMENWAY R. BULLOCK, Senior Engineer, Metallurgical Laboratory, Government Equipment Division, Raytheon Company, Maynard, Mass.
JOHN ALICO, Manager, New York Office, Day & Zimmermann, Inc, Philadelphia, Penna.

60-MD-3: **New Welding Processes**
JOHN J. CHYLE, Director of Welding Research, A. O. Smith Corporation, Milwaukee, Wisc.

60-MD-4: **Metal Fabrication by Explosives**
VASIL PHILIPCHUK, Manager, Special Projects Department, National Northern Division, American Potash & Chemical Corporation, West Hanover, Mass.

9:30 AM . . . HYDRAULICS . . . SESSION IV

CO-CHAIRMEN:
EDWARD M. GREER, President, Greer Hydraulics Inc, New York International Airport, Jamaica, NY.
JOHN A FARRIS, Manager, Engineering Liaison, Aircraft Porous Media Inc, Pall Corporation, Glen Cove, NY.

60-MD-5: **Current Status of Hydraulic Pumps and Some Trends**
EDWARD BROWN, Director of Engineering, Machinery Hydraulic Division, Vickers Inc, Detroit, Mich.

60-MD-6: **Hydraulic Fluids—Today and Tomorrow**
RICHARD L. LESLIE, Supervisor, Fluids and Chemistry Group, Research and Development Department, Vickers Inc, Detroit, Mich.

CONFERENCE MAY 23-26

Sponsored by ASME Machine Design Division

MAY						
SUN	MON	TUE	WED	THU	FRI	SAT
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22	23	24	25	26	27	28
29	30	31				

May 25 . . . Wednesday

9:30 AM . . . CONTROL SYSTEMS . . . SESSION V

CO-CHAIRMEN: DR E. L. HARDER, Director, Analytical Department, Westinghouse Electric Corporation, East Pittsburgh, Penna.

JOHN T. LYNCH, Manager, Electronic Department, Burroughs Corporation, Paoli, Penna.

60-MD-7: **Analysis of Control Systems by Analog Computers**

WILLIAM E. SOLLECITO, Systems Analysis Engineer, General Engineering Laboratory, General Electric Company, Schenectady, NY.

60-MD-8: **Computers in Control Systems**

DR ARTHUR S. ROBINSON, Assistant Chief Engineer for Advanced Research and Development, Eclipse-Pioneer Division, Bendix Aviation Corporation, Teterboro, NJ.

9:30 AM . . . MATERIALS . . . SESSION VI

CO-CHAIRMEN: ALBERT R. MEAD, Staff Engineer, Manufacturing Engineering Department, Grumman Aircraft Engineering Corporation, Bethpage, NY.

EDWARD N. HEGGE, Deputy Director, Watertown Arsenal Laboratories, US Army Ordnance Arsenal, Watertown, Mass.

60-MD-9: **Some Considerations in the Use of High Strength Steels**

A. M. HALL, Division Chief, Battelle Memorial Institute, Columbus, Ohio

60-MD-10: **Increasing the Performance of Nonmetallic Structural Materials**

WILLIAM E. DIRKES, Chief, Plastics Branch, Materials Laboratory, Wright Air Development Center, Wright-Patterson Field, Ohio.

9:30 AM . . . AUTOMATIC ASSEMBLY . . . SESSION VIII

CO-CHAIRMEN: GEORGE F. HAWLEY, Director of Development and Engineering, Automation Engineering Laboratory Inc, Stamford, Conn.

ALLAN HARVEY, President, Dasol Corporation, New York, NY.

60-MD-11: **Concept of Modular Design for Mechanized Assembly**

A. ARNOLD LAWSON, Consulting Project Engineer, Melpar Inc, Falls Church, Va.

60-MD-12: **Basic Design Parameters for Automatic Assembly**

ROBERT ESKEN, Supervisor, Engineering & Sales Application, Autometrology Section, Sheffield Corporation, Subsidiary of Bendix Aviation Corporation, Dayton, Ohio.

May 26 . . . Thursday

9:30 AM . . . USE OF COMPUTERS IN DESIGN . . . SESSION VIII

CO-CHAIRMEN: DR JULIUS S. ARONOFSKY, Manager, Electronic Computer Center, Socony-Mobil Oil Company Inc, New York, NY.

RAYMOND PAYNE, Supervisor, Engineering Computer Section, Worthington Corporation, Harrison, NJ.

PANEL MEMBERS: E. F. MAGNUSSON, Mathematician, Control Programming, General Engineering Laboratory, General Electric Company, Schenectady, NY.

GEORGE RYCKMAN, Supervisor, Data Processing Group, General Motors Research Laboratory General Motors Corporation, Detroit, Mich.

DR AARON FINERMAN, Manager, Digital Computing and Data Processing Division, Republic Aviation Corporation, Farmingdale, NY.

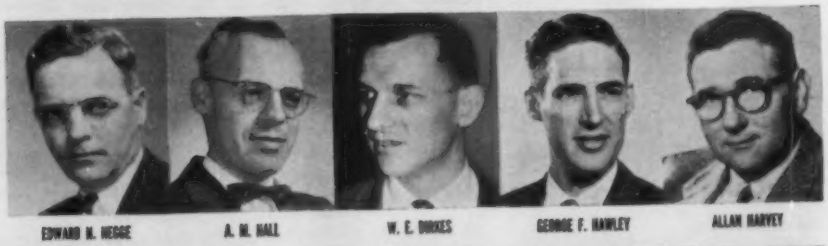
WHO'S WHO AND

HUGH L. DRYDEN | ARTHUR R. KANTROWITZ | WILLIAM H. GALL | VARICK D. SCHWARTZ | GEORGE P. SUTTON | ELMER P. WHEATON

FRANK McGINNIS | NICHOLAS OSIFCHIN | THOMAS C. REEVES | HARRY R. POWELL | HEMENWAY B. BULLOCK | JOHN ALICO | JOHN J. COYLE

VASIL PHILIPCHUK | EDWARD M. GREER | JOHN A. FARRIS | EDWARD BROWN | RICHARD L. LESLIE

E. L. HARDER | JOHN T. LYNCH | WILLIAM E. SOLLECITO | ARTHUR S. ROBINSON | ALBERT R. MEAD



EDWARD M. HEGGE | A. M. HALL | W. E. DUKES | GEORGE F. HAWLEY | ALLAN HARVEY

A. A. LAWSON | ROBERT ESKEN | JULIUS S. ARONOFSKY | RAYMOND PAYNE | E. F. MAGNUSSON | GEORGE RYCKMAN | AARON FINKMAN

WHAT'S WHAT...

NEW HORIZONS IN ENGINEERING DESIGN

PANEL SESSION

Space and nuclear design authorities will emphasize how engineering principles, relationships, and formulas developed for their fields of technology can be applied to improve design of commercial products. Included will be the applications of materials and components to meet extremes of environmental conditions and, at the same time, ultimate performance. High and low temperatures, erosion, corrosion, impact, vibration, miniaturization, reliability, and limited life will be discussed. This is a question and answer panel session with some short prepared talks by each of the panel members.

RELIABILITY PREDICTION—ITS VALIDITY AND APPLICATION AS A DESIGN TOOL

60-MD-1

THOMAS C. REEVES, Radio Corporation of America

An introductory survey to reliability prediction. The author divides the theme into three main parts: what reliability prediction is and the conditions which must accompany its intelligent use; validity of such predictions; and uses to which it can be put. Among the latter are: operations analysis, maintenance and logistic studies; design and value analysis. Examples of reliability prediction are presented. Although the mathematics and statistics are minimized for brevity, source documents are cited.

IMPACT OF RELIABILITY ON DESIGN

60-MD-2

HARRY R. POWELL, Space Technology Laboratories, Inc

What does this mean to the designer? It means that reliability must be a factor in design from inception. Also, that many of the old established design concepts no longer suffice. Designers today must be aware of all the conditions of use which can cause unreliability and must take these factors into account in the initial design. Designers must know about the special techniques which have been developed. These include the use of redundancy, designing for unusual ruggedness under vibration and temperature, provisions for marginal testing, and derating components.

NEW WELDING PROCESSES

60-MD-3

JOHN J. CHYLE, A. O. Smith Corporation

The newer metals—developed for the space and atomic age—have characteristics and properties that require new methods of processing and procedures for welding. Pressure welding, fusion welding and brazing are the broad groups. Selection of group, process and procedure, is governed by type of metal to be joined, design of the weldment, cost of welding, and the engineering and service requirements. Further developments on new welding processes, new welding power sources, and new concepts in welding are to be expected. For example, rocket-propellant solid fuels show promise as a heat source for fusion welding.

METAL FABRICATION BY EXPLOSIVES

60-MD-4

VASIL PHILIPCHUK, American Potash & Chemical Corporation

The new field of metal-parts fabrication by explosive forces is being used to size, form, forge, weld, compact, and condition. It is expected that explosive force fabrication will be an adjunct to old and present-day techniques. It will be selective from both the standpoint of economics and for its ability to accomplish a fabricating operation. High quality, close tolerance, and fast deliveries can be achieved through explosive force fabrication.

CURRENT STATUS OF HYDRAULIC PUMPS AND SOME TRENDS

60-MD-5

EDWARD BROWN, Vickers, Inc

Aeronautical, mobile and industrial hydraulic equipment is in for a change during the next decade. In the aeronautical field, higher pressures and temperatures are forecast as well as increased pump speeds. Hydrostatic transmissions will replace hydrokinetic units in mobile equipment because of higher efficiencies and better control. Electrohydraulic systems—combining computer control and hydraulic power—will continue to expand in the industrial field. Standardization will reduce cost and improve reliability and serviceability.

HYDRAULIC FLUIDS—TODAY AND TOMORROW

60-MD-6

RICHARD L. LESLIE, Vickers, Inc

Selection of the proper fluid for any application requires a detailed study of the system, its operating conditions and performance requirements. The fluid is a component of the system and its selection is considered at the time of system design. Some newer applications—where fire, temperature extreme, or nuclear bombardment exist—still have problems, but development work being conducted will improve fluid performance in these areas. Improvements will be also accelerated as laboratory testing methods are developed that correlate closely with field-testing and actual experience.

continued on next page

WHO'S WHO AND WHAT'S WHAT . . .

ANALYSIS OF CONTROL SYSTEMS BY ANALOG COMPUTERS

60-MD-7

WILLIAM E. SOLLECITO, General Electric Company

Advances in the computer art now permit control systems to be designed by simulating the action of variables on an analog computer. Paper presents the fundamentals of analog computers and how they are used to solve system design problems. Tables of commonly encountered transfer impedances and nonlinear simulation networks are given for ready reference.

COMPUTERS IN CONTROL SYSTEMS

60-MD-8

ARTHUR S. ROBINSON, Bendix Aviation Corporation

Basic considerations that must be analyzed before computer control systems can be expanded include: problems to be solved; method of solution; cost of problem solution equipment; and equipment complexity. At present, advances are possible based on known digital computing techniques, but to make these advances rapidly and efficiently control system design and engineering must be combined with advanced digital techniques.

SOME CONSIDERATIONS IN THE USE OF HIGH STRENGTH STEELS

60-MD-9

A. M. HALL, Battelle Memorial Institute

The increasingly rigorous demands of the aircraft and missile industry have constituted the major impetus behind the development of steels in the tensile strength range of 180,000 to 300,000 psi. Experience has indicated improved methods of making and handling, given a better understanding of the advantages and limitations of each class, and permitted property improvements. Though many problems still exist, many have been solved. Discussed are: low-alloy hardenable steels; chromium hot-work die steels; martensitic stainless steels; semi-austenitic precipitation hardenable steels; and cold-rolled austenitic stainless steels.

INCREASING THE PERFORMANCE OF NONMETALLIC STRUCTURAL MATERIALS

60-MD-10

WILLIAM E. DIRKES, Wright Air Development Center

Increased temperatures have led to the development of a new family of nonmetallic structural materials. Paper describes the advantages and limitations of these materials, and offers an approach to obtain optimum properties based upon application. Materials included are: glass fiber reinforced plastics and adhesives, sandwich construction materials, ablation materials, materials systems, and composite materials—materials in combination.

CONCEPT OF MODULAR DESIGN FOR MECHANIZED ASSEMBLY

60-MD-11

A. ARNOLD LAWSON, Melpar Inc

Intent is to point out the possibilities of extending the basic concept of modular construction and production techniques, such as used in the electronic industry, into other fields—especially mechanical equipment. Modules permit interchangeability, replaceability, and use in more than one assembly or system. In mechanical equipment, five basic units are included: feeding, positioning, assembling, power, and control. And mechanized equipment is not necessarily limited to the production of "long runs" only. In many applications it is equally feasible for "short runs," especially if there is a cost savings at changeover.

DESIGNING PRODUCTS FOR AUTOMATIC ASSEMBLY

60-MD-12

ROBERT ESKEN, Sheffield Corporation

In automatic assembly, product design plays an important part by incorporating into the design of each component the characteristics that permit automatic conveying, feeding, positioning and inspection. Any part presents a problem to one or more of these, but must be solved before automatic assembly is possible. Paper gives some typical problems and their solutions.

USE OF COMPUTERS IN DESIGN

PANEL SESSION

Among the points discussed will be: types of design problems that can be computer solved; computer types and sizes available; how to schedule and integrate a computer section into the over-all engineering setup; personnel training; cost of installations and operations. Panel is composed of computer users who have successfully solved these and other problems.

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Conference papers will be bound into book form and given to all conference registrants. Additional copies of the conference book will be available at the conference only for $5. per copy.

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CIRCLE 119 ON READER SERVICE CARD 119

THESE 13 SPECIAL ALLOYS FROM *can help you solve design problems . . .*

As the result of the knowledge gained over the years by working closely with hundreds of customers in helping solve innumerable design and production problems, the Mueller Brass Co. has developed a series of special alloys for use in tough or unusual applications.

This group of special alloys, each having distinct characteristics and advantages, are available in rod form in many sizes and shapes as well as forgings.

CHARACTERISTICS AND APPLICATIONS	ALLOY NO.	NAME	TEMPER
TUF-STUF® ALUMINUM BRONZES AND NICKEL ALUMINUM BRONZES have great strength characteristics. All are more resistant to corrosion cracking under load than copper-zinc alloys and, in addition, some are heat-treatable. They can withstand heavy pounding and have proved excellent for such parts as gibs, cams, valve seat inserts, shifting forks and propeller hub cones.	224E-30	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 165
	224E-75	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 175
	224C	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 185
	224H	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 200
	224K	"Tuf-Stuf" Nickel Aluminum Bronze	BRINELL 3000 KG load 250
ALUMINUM SILICON BRONZE is free turning; has high strength, is corrosion resistant and non-magnetic and resistant to corrosion cracking under load.	802	Aluminum Silicon Bronze	ROCKWELL-B 75
600 SERIES® FORGEABLE BEARING ALLOYS range from high strength to low leaded ductile. All are corrosion resistant, free cutting, can be used with hard or soft mating members and can be soldered. They are employed in a great variety of applications ranging from pump gears and valve stems to pinion shafts and transmission rings.	600	Forgeable Bearing Alloy	ROCKWELL-B 88
	601	Forgeable Bearing Alloy	ROCKWELL-B 87
	602	Leaded Forgeable Bearing Alloy	ROCKWELL-B 87
	604	High Leaded Forgeable Bearing Alloy	ROCKWELL-B 86
	605	Low Leaded Forgeable Bearing Alloy	ROCKWELL-B 80
MANGANESE BRONZE ALLOYS are exceptionally strong, tough, resistant to shock and corrosion. Good for screw machine products and forgings for aircraft parts.	241A	Manganese Bronze A	ROCKWELL-B 85
	721	Manganese Bronze High Tensile Grade B	BRINELL 1000 KG load 200
TELLURIUM COPPER has very high electrical and thermal conductivity combined with good corrosion resistance and machinability. Excellent for electronic components.	799	Tellurium Copper	ROCKWELL-B 45

NOTE: The values shown are average values normally obtained in production. Variations must be expected in practice. The values should be used as a general guide rather than the basis for specifications.

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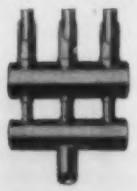

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65,000	100,000	30
62,000	95,000	35
70,000	90,000	30
65,000	105,000	20
25,000	85,000	60
60,000	90,000	25
55,000	78,000	35
65,000	85,000	65
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55,000	78,000	25
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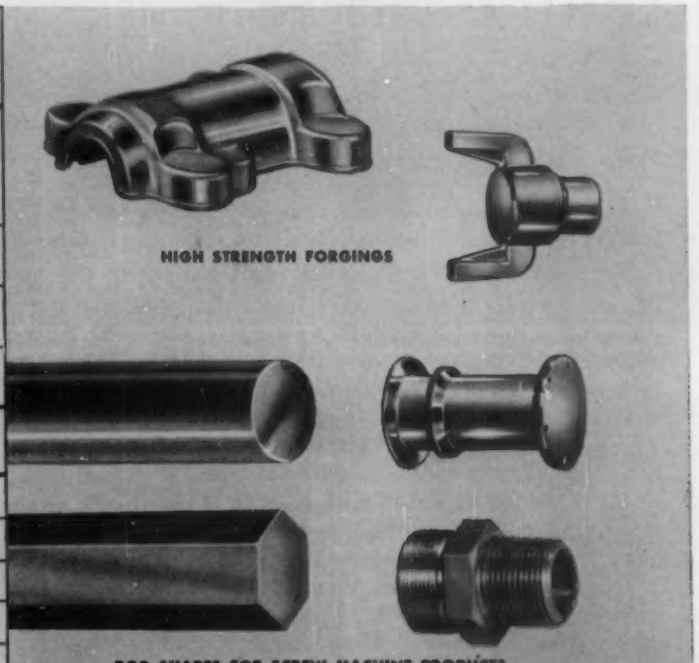
40,000	43,000	90



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ROD SHAPES FOR SCREW MACHINE PRODUCTS

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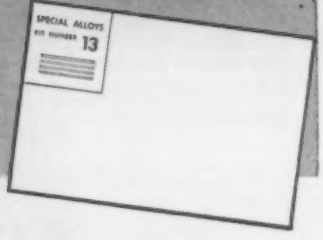

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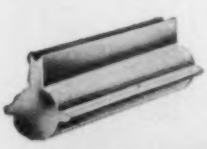
SAND CASTINGS



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CIRCLE 121 ON READER SERVICE CARD 121

HOW DOEHLER-JARVIS' DAY-TO-DAY SERVICE HELPS MELNOR MASS PRODUCE HIGH QUALITY LAWN EQUIPMENT

Melnor Industries, Inc., is the leader in garden sprinklers and related hose hardware . . . items designed to high mechanical standards, modernly styled, priced for volume sale.

From the start, most parts of most items in the Melnor line have been die cast by Doehler-Jarvis . . . for reasons that Melnor sums up in the simple phrase, "day-to-day service."

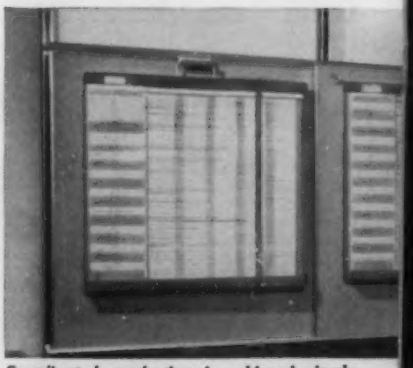
But this is a phrase that needs illumination, needs specifics.

Just what does Doehler-Jarvis include in this "day-to-day service" that means so much to die castings customers? As you might expect, Doehler-Jarvis provides all customary services, such as tapping, drilling, milling and other pre-assembly work. Doehler-Jarvis provides important extras, too . . . extensive assistance in parts design, for example, and complete finishing facilities. Even sub-assembly may be negotiated, if desired.

But more important than these is a sort of informal "partnership for production" . . . where key people in D-J keep in daily touch with their opposite numbers . . . with D-J's sales engineer coordinating all along the line. Through this mutual understanding and interchange of process knowledge, design is continually improved, costs continually reduced. Often difficulties are anticipated and entirely avoided by the close *personal* contact that exists at all working levels with Doehler-Jarvis customers.

Pictures at right show some of the points of contact . . . show some of the Doehler-Jarvis facilities that make this unique working relationship pay off for Melnor . . . as a comparable relationship might for you.

Close liaison during die design does much to keep Melnor's costs down. At this stage slight modifications in die or part often eliminate one or more operations. To attain this flexibility, D-J designs and makes its own dies.



Coordinated production is achieved simply. It's done by a daily telephone call that establishes Melnor's needs for the next two days.

Doehler-Jarvis

Division of
NATIONAL LEAD COMPANY
General Offices: Toledo 1, Ohio
Plants at:
Toledo
Grand Rapids 2, Mich.
Pottstown, Pa.
Batavia, N. Y.

In Canada: **Barber Die Casting Co. Limited**
Hamilton, Ontario

In Brazil: **Industrias Doehler do Brazil, Ltda.,**
Sao Bernardo do Campo, Sao Paulo

Idea exchange starts early! You are looking in on a tough-minded, sharp-pencil work session. At this one, Melnor and Doehler-Jarvis decision makers are setting basic production requirements for a new sprinkler model. During production informal meetings between individual members of this group will keep production moving smoothly.

Joint meetings establish production cost limits. Then D-J automates to bring costs within requirements. Ordinarily, automatic tooling is developed and made in Doehler-Jarvis' own shops...as was this 12-station, indexing tool.

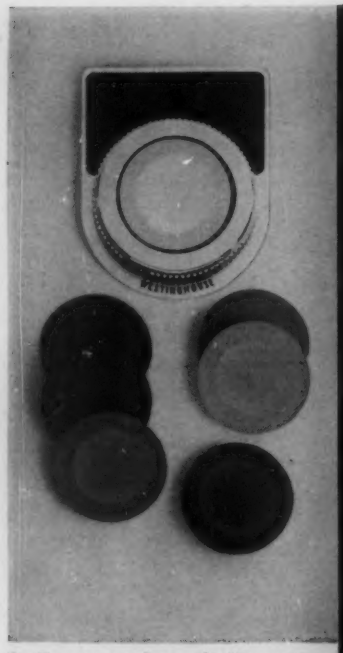
Two heads have proved better than one in giving Melnor products durable low-cost finishes, so specialists from both companies confer frequently. D-J both plates and paints. Modern inspection guards finish quality.

Mutual considerations bring packing innovation. Until recently, D-J shipments went to Melnor in throw-away packages. To save money and time at both plants, D-J engineers designed the money-saving re-use container above.

Before closing, D-J has its trucks loaded for the next day's delivery and has started preparing shipments for the succeeding day.

Plant-to-plant delivery is direct and fast. Shipments to Melnor go in one or more of Doehler-Jarvis' own tractor-trailors, arriving early in the morning. Coordination is so close that neither plant is called upon to carry high parts inventories.

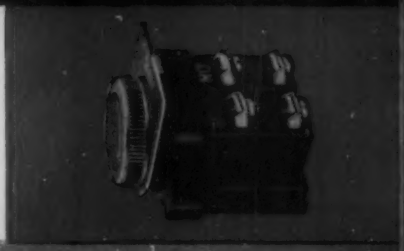
CIRCLE 123 ON READER SERVICE CARD



Easily snapped-on plastic caps come in seven colors—red, green, blue, yellow, gray, tan and black—for quick color coding of a pushbutton bank.

Assembled units (right) permit multiple contacts in limited space. As many as six contact blocks can be coupled to a single pushbutton.

Westinghouse Flush Pushbutton (below) with contact blocks. Notice how one fits directly behind the other. Stacking permits controlling many circuits with one button.



YOU GET...
TOTAL DESIGN FLEXIBILITY IN THE WESTINGHOUSE FLUSH PUSHBUTTON

circuit flexibility—unique spacesaving design permits as many as six contact blocks to be stacked one behind the other. You operate all circuits with one push of a button . . . a big help when multiple operations are necessary.

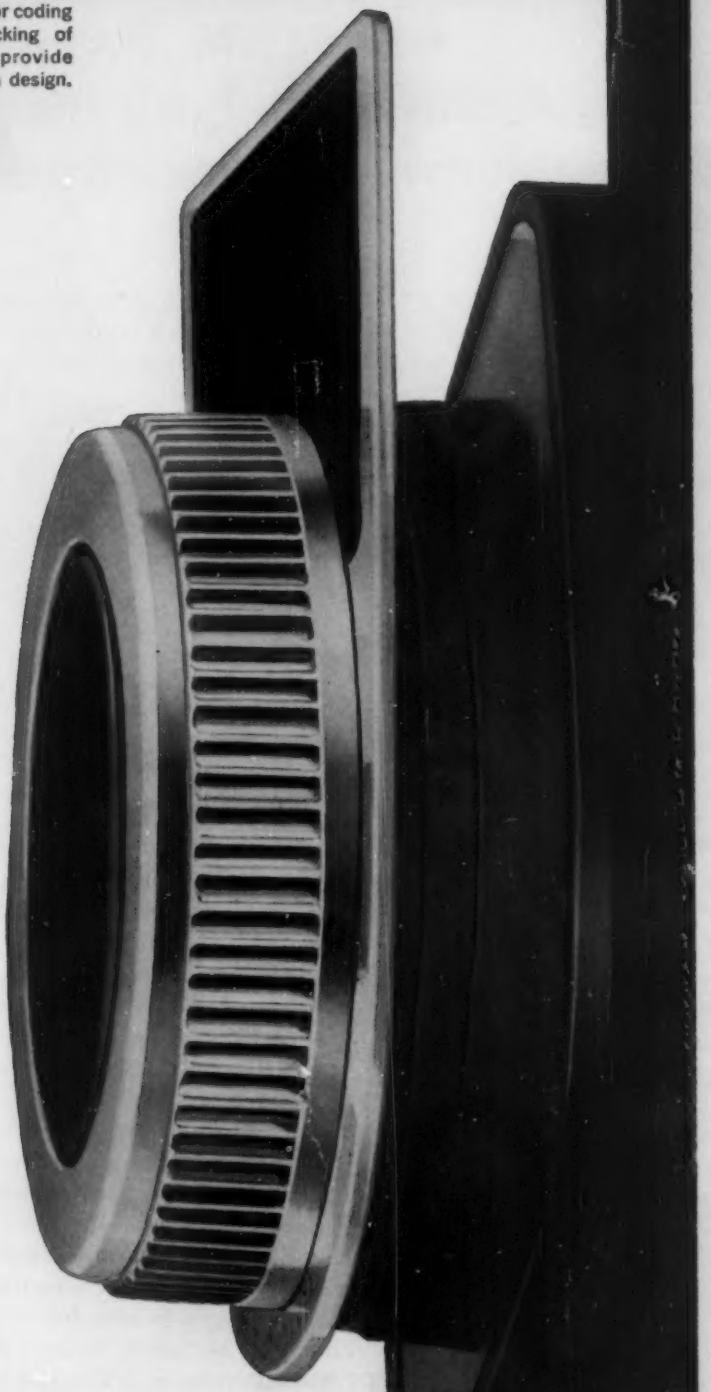
color flexibility—interchangeable chemical-resistant plastic caps come in seven colors: red, green, blue, yellow, tan, gray and black. Choose the best pushbutton for your design and color code it. Permits programming of manual operation using only one model.

function flexibility—choose from a wide range of operators to suit any use. Standard units available include flush head, mushroom head, extended head, selector switches, push-to-test indicating lights and a host of others.

When your design calls for pushbuttons, you'll find what you need in Westinghouse stock. Call your nearest Westinghouse representative, or write Westinghouse Electric Corporation, Standard Controls Div., Beaver, Pennsylvania. J-30313

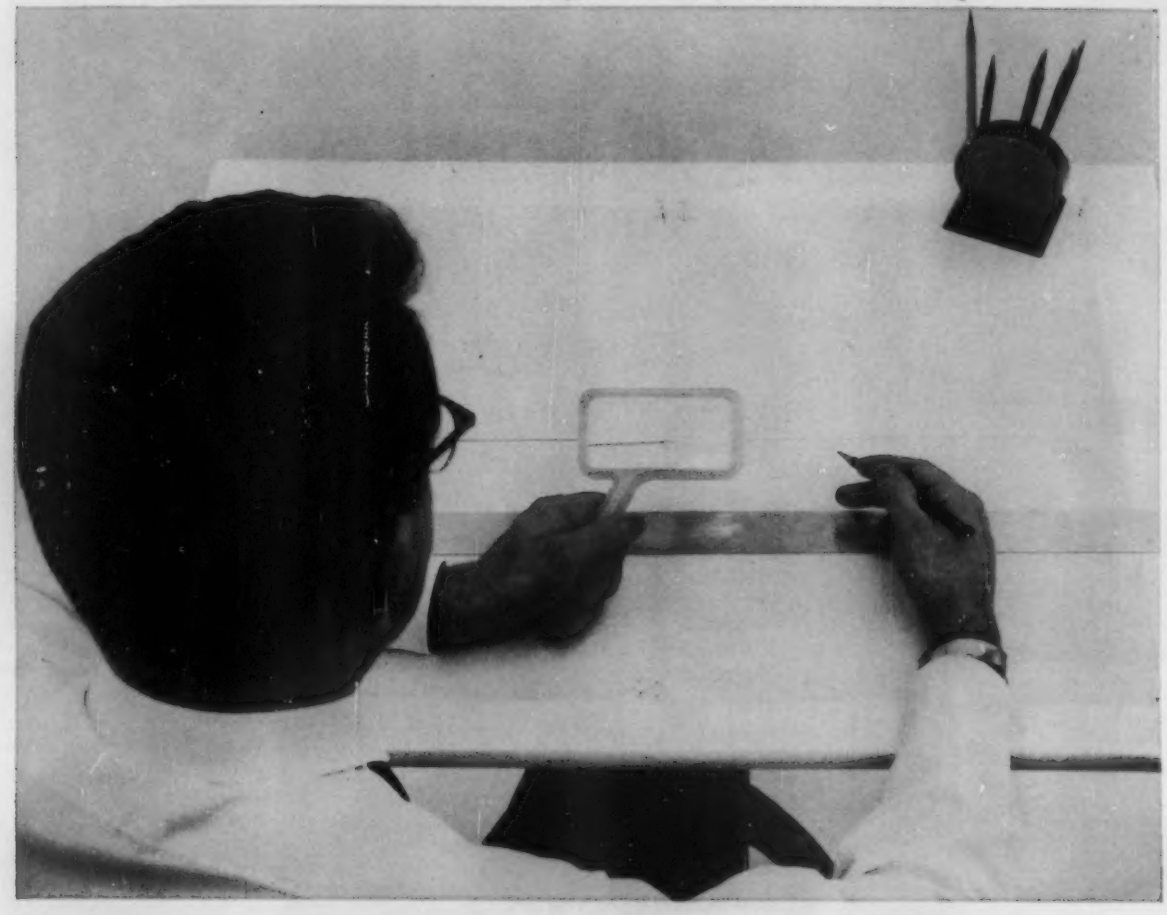
YOU CAN BE SURE...IF IT'S Westinghouse

The Westinghouse Flush Pushbutton . . . color coding and multiple stacking of contact blocks provide greater flexibility in design.



CIRCLE 125 ON READER SERVICE CARD

Simple Pencil Test Affords Dramatic Proof:



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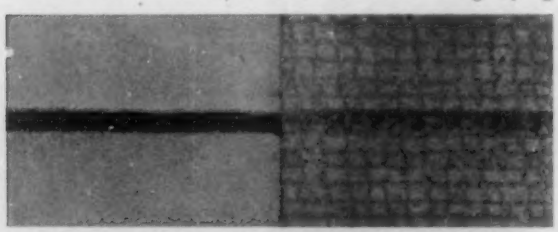
Here's an easy way to prove to yourself the superior draftability of CRONAFLEX: place a sheet of it on your drawing board, side by side with whatever drafting material you've been using. Now draft several lines on each. Erase and re-draft. Use your own tools, your own techniques.

Examine the lines you've drawn with a magnifying glass. Notice the difference in covering power, cleanness of erasures and line density—especially where lines have been re-drawn. You've just demonstrated three important reasons why CRONAFLEX is the best drafting film available: excellent *pencil acceptance*, outstanding *erasability* and good *re-drafting characteristics*.



Compare pencil acceptance of CRONAFLEX (left) with that of ordinary drafting material. Same pencil made both impressions! CRONAFLEX gives a faster, cleaner, lighter touch, too, because you don't have to bear down as you must with cloth.

CRONAFLEX has other advantages, as well. Its rugged "Cronar"* polyester base holds its size and resists kinking. It's .004" thick for easier, more efficient handling. Because CRONAFLEX is manufactured from start to finish by Du Pont, you're assured of consistent performance found in no other drafting film. To learn more, write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware.

*Du Pont's trademark for its polyester photographic film base.

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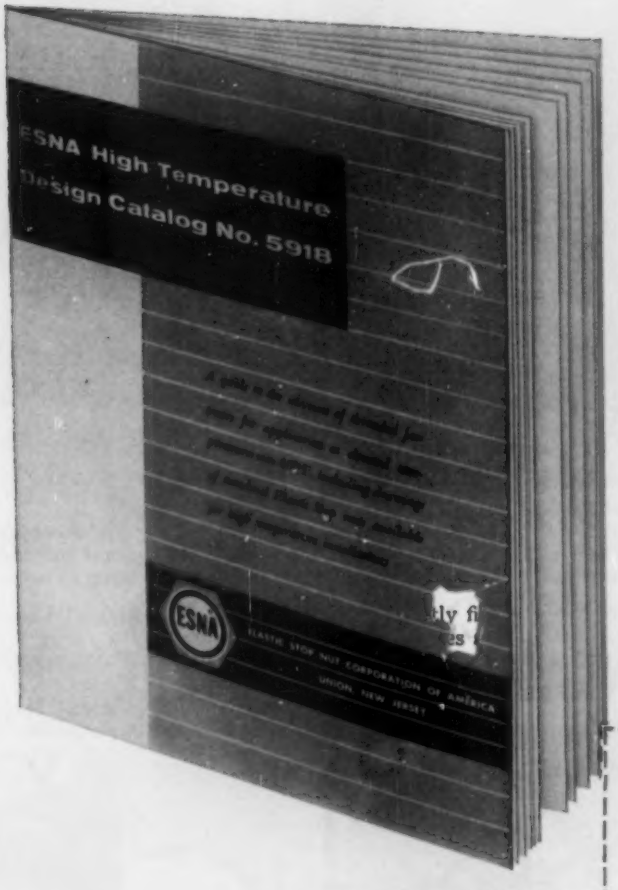
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

NEW FASTENER GUIDE

for Spacecraft, Missile and Power Plant Engineers with high temperature assembly problems

New ESNA® 80-page guide reflects fifteen years of research and design experience as the original producer of high temperature self-locking nuts for the gas turbine industry.



INDEX PROVES CATALOG'S VALUE:

Section I—First 17 pages contain a resume of technical data pertaining to high temperature terminology and such phenomena as stress rupture, creep, relaxation strength and other vital subjects you should consider before specifying.

Over 50 pages of fully detailed standard drawings...

Section II—Fasteners for use to 900° F.

Section III—Fasteners for use to 1200° F.

Section IV—High performance fasteners for use to 1200° F.

Section V—Fasteners for use over 1200° F.

Section VI—General production and design data covering the use of shank nuts for internal bolting application in gas turbine engines.

Section VII—Design data covering the application of circular gang channel on gas turbine flanges.

MAIL COUPON TODAY!

ELASTIC STOP NUT CORPORATION OF AMERICA

ELASTIC STOP NUT CORPORATION OF AMERICA,
Dept. S41-545 UNION, NEW JERSEY

Please send me now ESNA High Temperature Design Catalog #5918.

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CIRCLE 127 ON READER SERVICE CARD

SOLVING MATERIAL DESIGN PROBLEMS
HEAT RESISTANCE
A 5000° flame has not penetrated a one-quarter-inch piece of CDF's new Dilecto RD-105 laminate after ten minutes. The same thickness of cold-rolled steel is pierced in less than forty seconds.

Molded from graphite fabric impregnated with a heat (ablation)-resistant phenolic resin, new CDF grades RD-105 and RD-115 are being evaluated in solid propellant rocket motors.

Dilecto laminates are only one family of products from industry's largest selection of non-metallic structural materials and electrical insulations. Vulcanized fibre, silicone rubber, mica, Teflon*, and thermosetting moldings are also supplied by CDF.

CDF can provide both quality and true economy in selecting plastic materials best suited to your needs. Refer to SWEETS PD file or write to us for [illegible]l Folder 60.

*DuPont trademark

CDF **CONTINENTAL-DIAMOND FIBRE**

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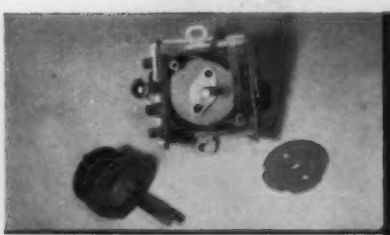
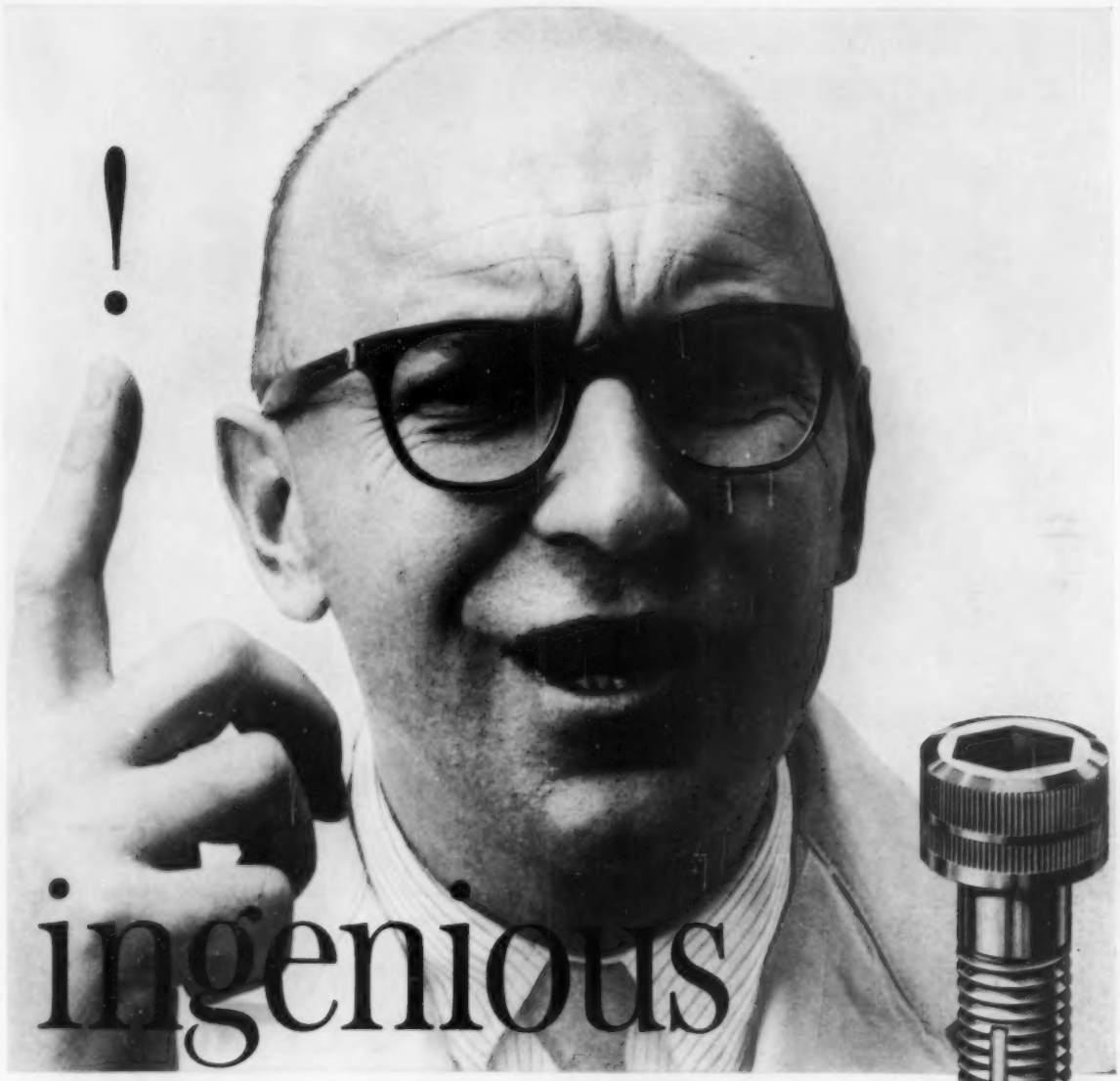


Moisture-resistant and low cost Dilecto cams for automatic washer and dryer controls.

Dimensionally stable, light weight, oil-resistant Dilecto ball bearing retainer rings.

Easily fabricated paper-base, punching grade Dilecto precision switch insulators.



New P-K® Socket Screws with Long-Lok® Inserts

Notice the groove in the thread. It's permanently filled with Polycap, a nylon type polymer that provides self-locking action over a wide temperature range.

Simple? True! It's an efficient, practical solution to 1001 problems . . . wherever vibration is present—where adjustment is required—where re-use is a factor.

In industrial and consumer products . . . in electronics, engines, hydraulics, valves, supersonic guided missiles—P-K Socket Screws with Long-Lok Inserts give you many advantages . . .

- Higher resistance to shock and vibration
- Superior thread engagement and locking force
- Higher percentage of reusability
- Eliminates the need for lock washers, safety wires

A COMPLETE LINE—You can get P-K socket head cap screws (1936 and new 1960 "Prelode" Series); set screws, including the revolutionary P-K W-Point*†; button heads, flat heads, shoulder screws and pipe plugs; all *with* or *without* the Long-Lok insert. And don't forget P-K quality-controlled dowel pins, hex keys and key kits!

Ask your P-K distributor for samples and technical data, or write directly to Parker-Kalon for bulletin No. 862.

*T. M. †U. S. Patent No. 2,907,245

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BOOTH 635

PARKER-KALON, a division of General American Transportation Corporation, Clifton, N. J. Offices and warehouses in Chicago and Los Angeles.

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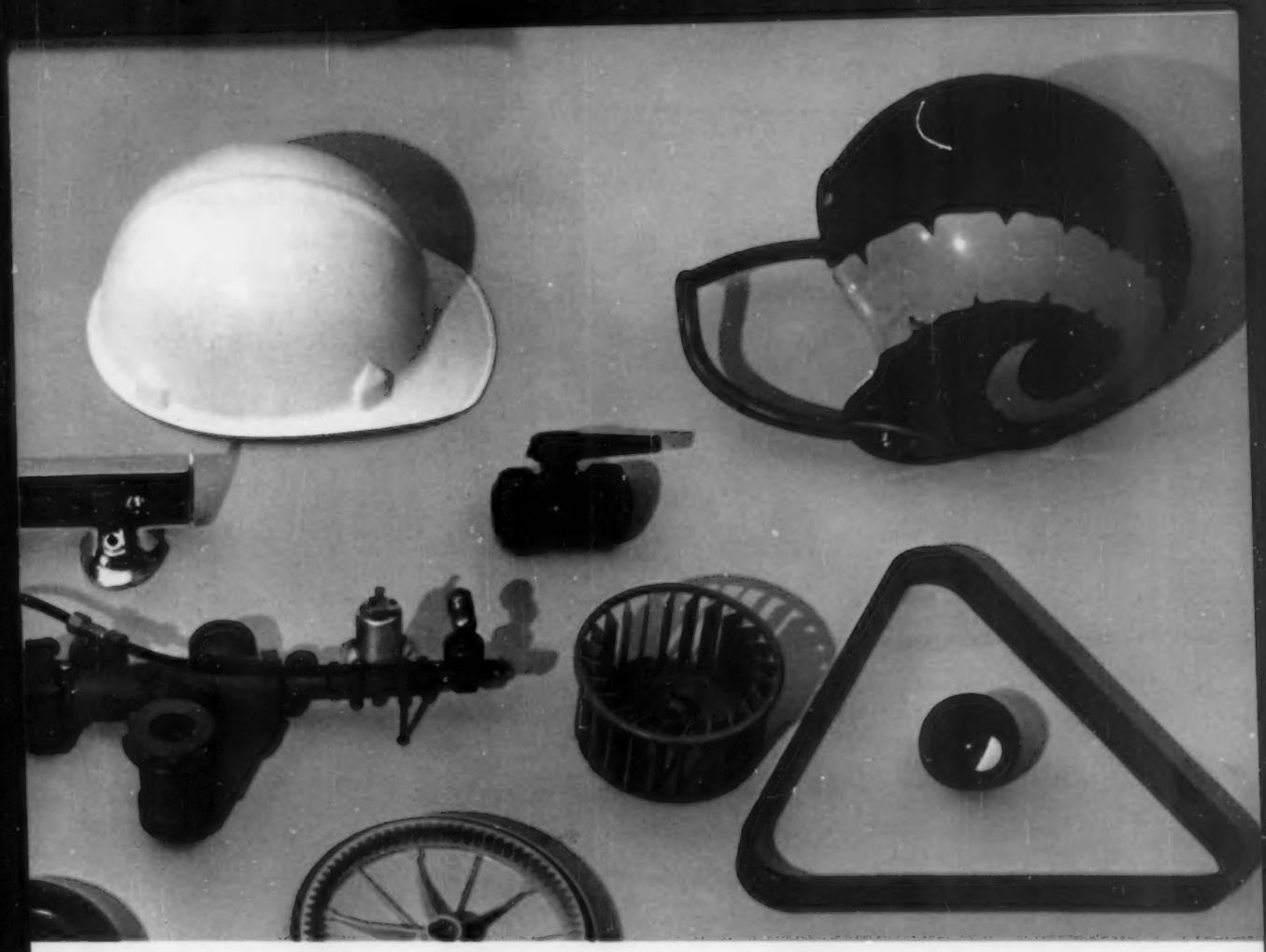
CIRCLE 130 ON READER SERVICE CARD→

Naugatuck KRALASTIC

Announcing
KRALASTIC MH
...newest in the
family of
Design-Engineering
ABS Plastics

- **HIGH GLOSS**
- **EASIER PROCESSING**
- **FASTER MOLDING**
- **EXCELLENT APPEARANCE**



Newest in the constantly expanding family of tough KRALASTIC® compounds, the original ABS resins, KRALASTIC MH has been developed especially to meet the requirements of those whose operations call for faster production cycles.

Yet with all its ease of processing, it sacrifices none of the impact strength which has made KRALASTIC the preferred material for hundreds of toughness-demanding applications.

In addition to its unusual combination of processability and impact strength, KRALASTIC MH also offers a high heat stability exceeding that of many other plastic materials. And its ability to take and hold a high gloss produces a lustrous product with strong and lasting sales appeal.

MH shares with the other KRALASTICS such typical properties as wide chemical resistance, unusual ability to withstand abrasion, and good electrical characteristics. These properties recommend this new material highly for sheet and profile extrusions, injection moldings . . . for a wide variety of products ranging from appliance housings to shoe heels.

Send for further information on the properties and application possibilities new KRALASTIC MH offers.

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United States Rubber

Naugatuck Chemical Division

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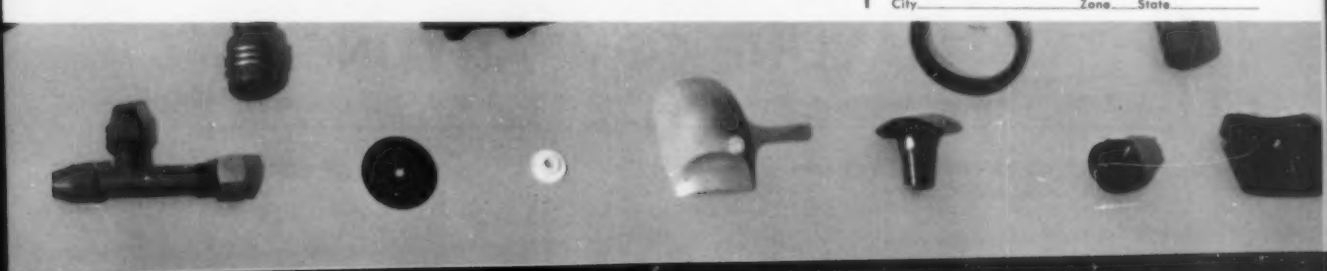

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Outstandingly different!

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DESK-O-MATIC

The *NEW* desk height drafting table.

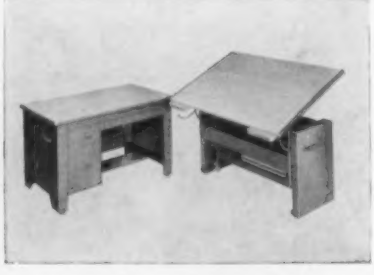
The Desk-O-Matic is the only fully adjustable, automatic, desk high drafting table that permits the operator to change angle of top or height of top, instantly, without moving from his position at the front of the table.

Also, this table has counterbalance adjustments to insure consistent smooth operation of changes in both top height and tilt, and to compensate for weight added to top by drafting machine, light, and other equipment. The Desk-O-Matic drafting top holds steady regardless of height or angle position.

Mayline invites you to see this new table when you attend the Design Engineering show in New York. Your inquiry to the factory will bring literature promptly.

DESIGN ENGINEERING SHOW
BOOTHS 1615-1617

May 23-26, 1960
New York, New York



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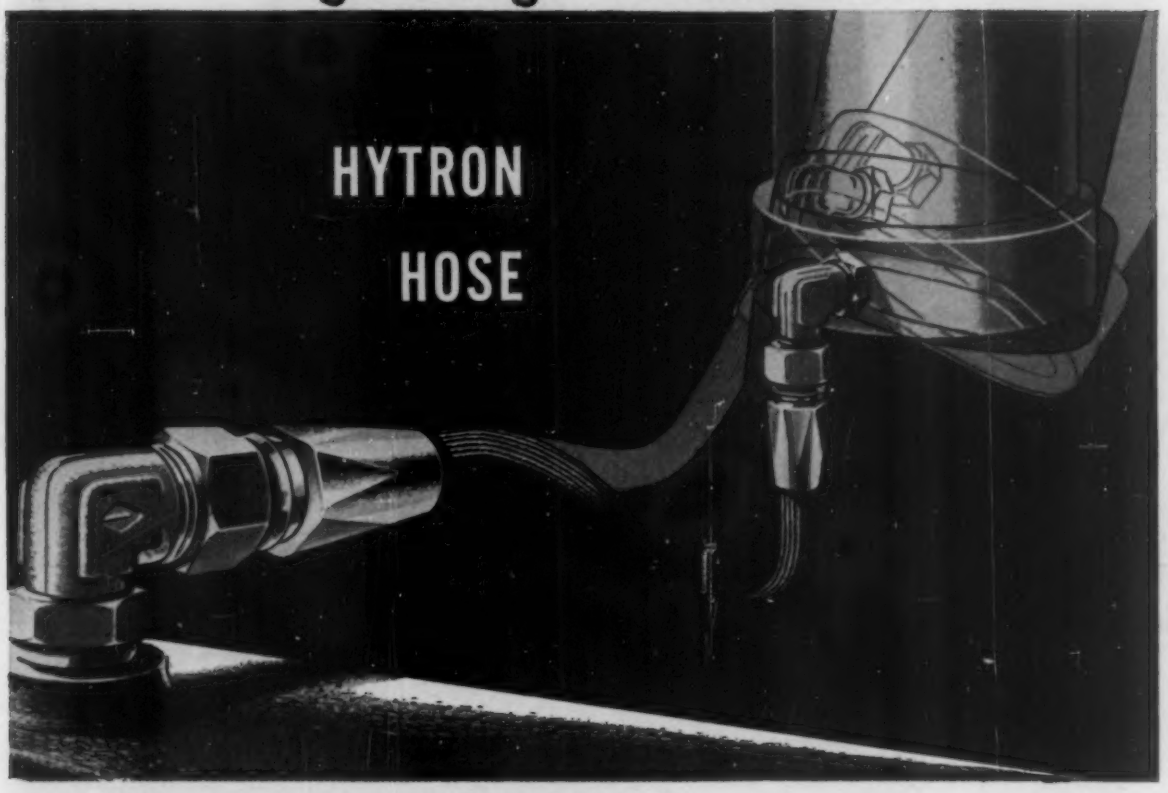

FAR GREATER FLEX-IMPULSE CAPACITY...
IMPROVED PRESSURE HOSE PERFORMANCE

Imperial unveils a completely new concept in pressure hose — opening new opportunities in hydraulic and pneumatic circuitry design, bringing new economies and advantages to thousands of other hose applications.

Hytron was created to solve many of the problems encountered in using S.A.E. types 100R1 and 100R5 hose. It radically reduces hose size and weight, offering smaller O.D. for equivalent pressure capacity and I.D.

Flex-Impulse Test Results

Hytron superiority under punishing flex-impulse conditions has been clearly demonstrated. Comparable 24" lengths of hose with couplings were subjected to cycles from 0 psi to 3500 psi at one-second intervals. Simultaneously they were flexed at 60 times per minute.

After 57.4 hours the S.A.E. 100R5 single wire braid rubber hose burst near a coupling. It took 415.5 hours — *over seven times as long* — before the Hytron hose failed.

Note that there is *no wire braid* in Hytron hose. This eliminates one of the major causes of fatigue failure. Hytron is 80% lighter in weight, and, unlike wire braid rubber hose, retains virtually all of its flexibility under pressure.

Imperial Hytron hose operates in a burst pressure range from 9000 to 12,000 psi, depending on size and temperature. It is recommended for continuous service with fluids from −40 to 225°F, and for intermittent service to 250°F. Hytron is unaffected by nonflammable hydraulic fluids up to 180°F and flammable fluids up to 225°F.

Hytron hose is available in exceptionally long lengths. Furnished as factory-made assemblies, or with easy-to-install reusable couplings. Hytron couplings are of a new design that greatly minimizes flow restriction, offering up to 157% greater flow capacity.

IT'S IN THE BOOK

A new engineering report on Hytron hose and couplings contains detailed test results and performance figures. Send for your copy of Form No. NEPR-500 today.

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Chicago 48, Illinois

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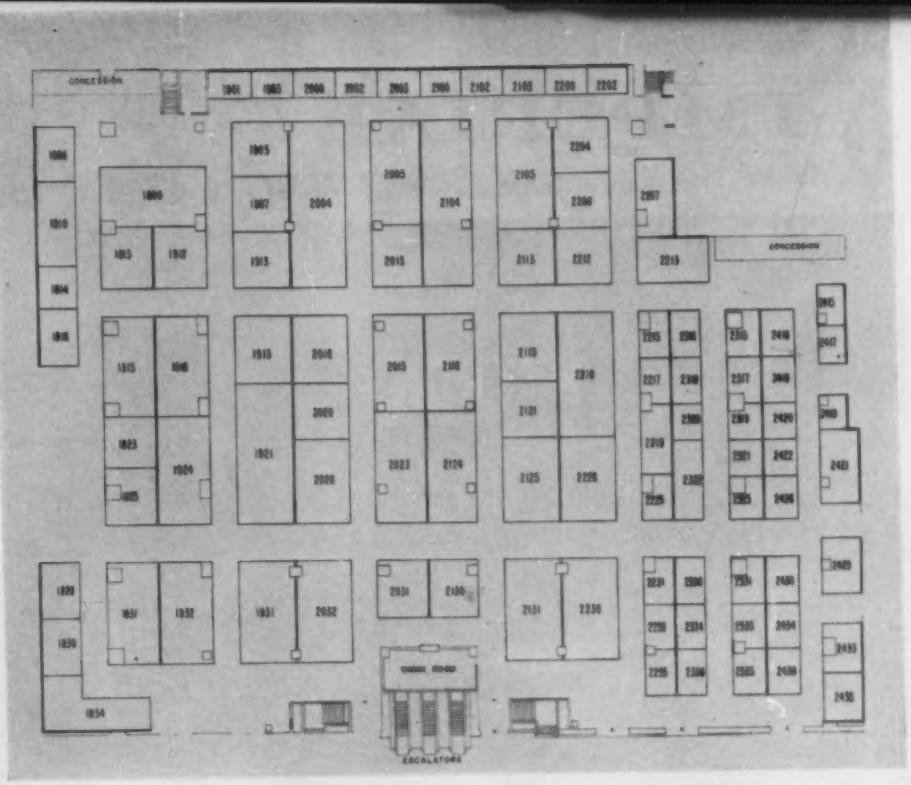
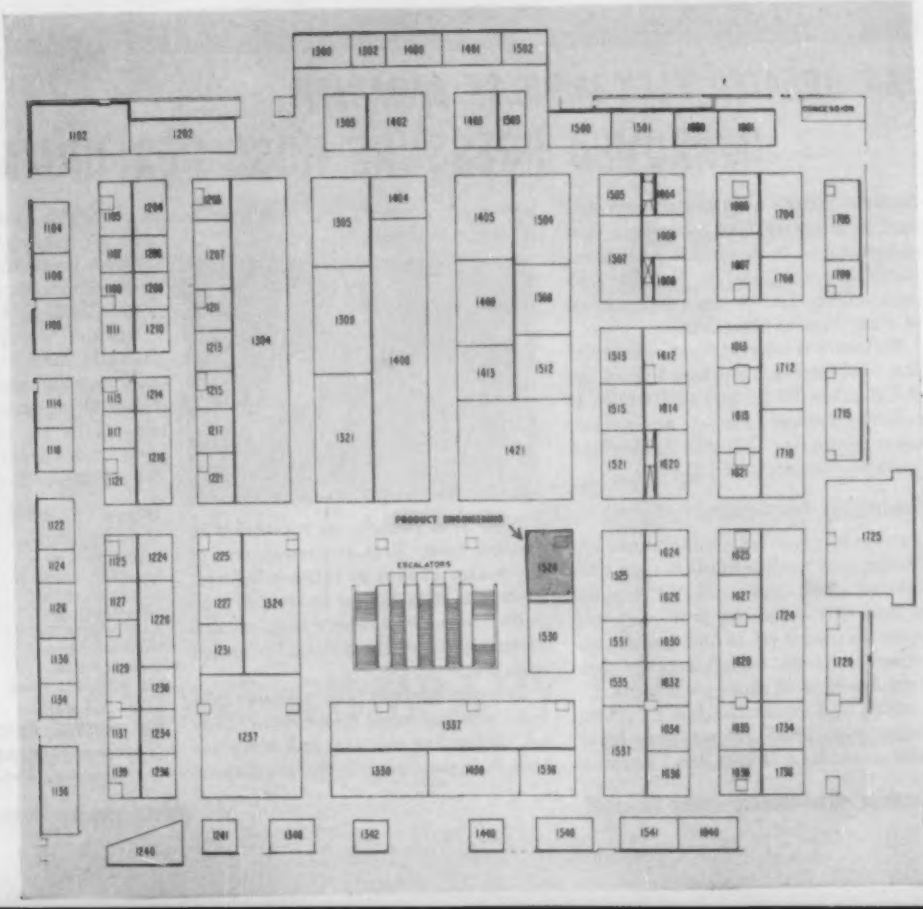
NEW PRODUCTS

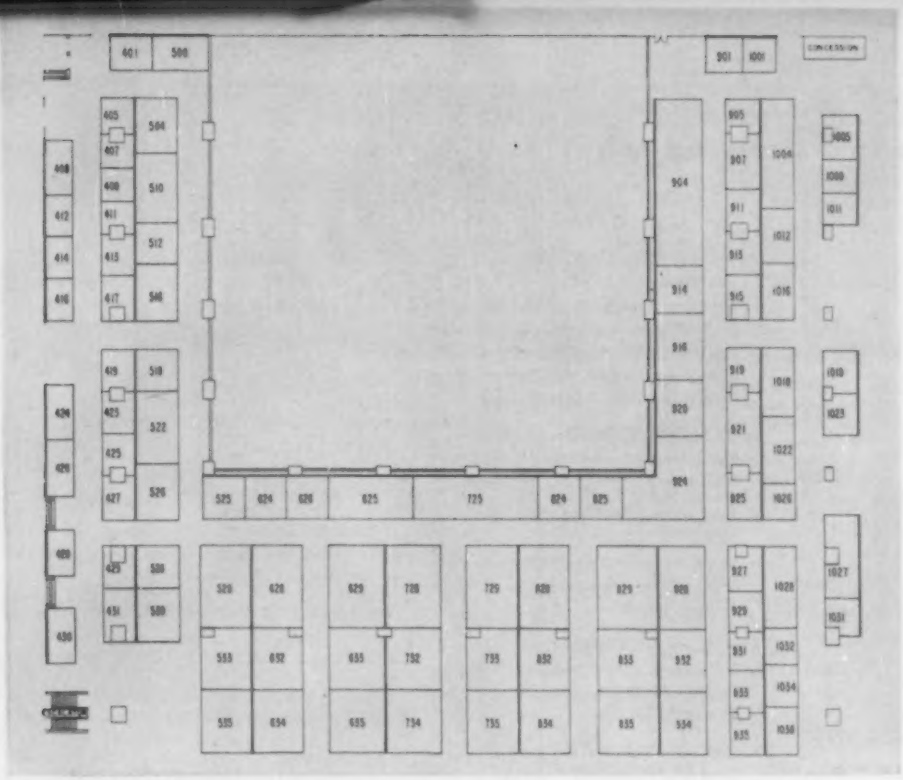


1st Floor
Coliseum, NYC

DESIGN SHOW FLOOR PLAN . . .



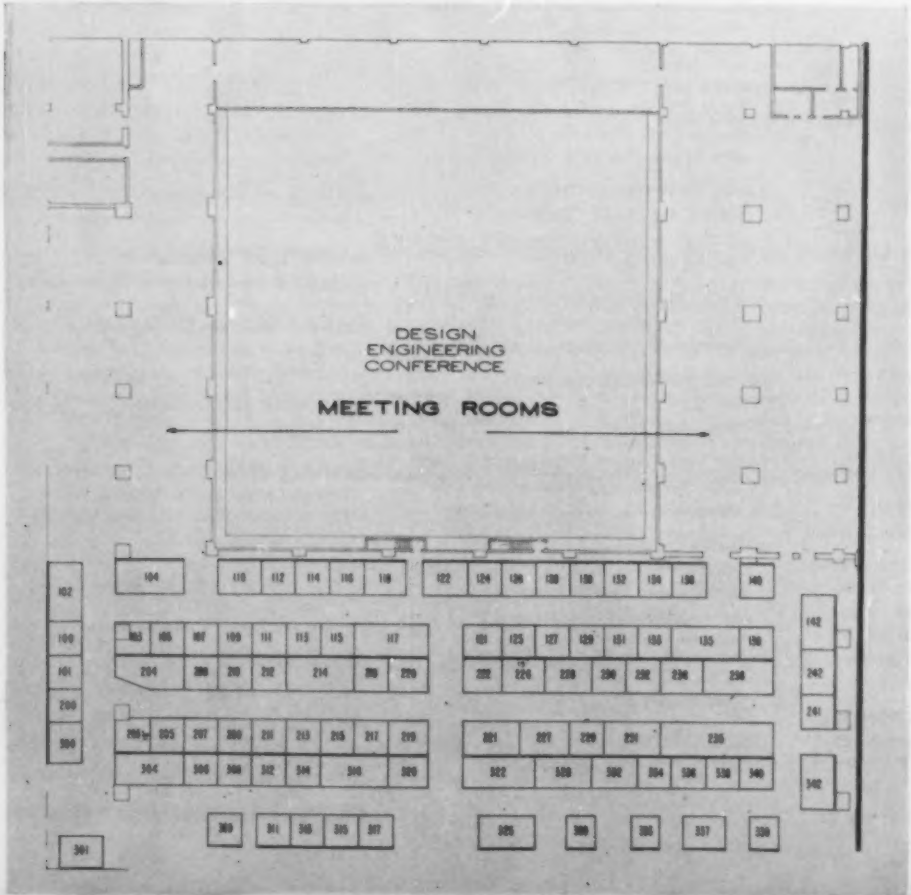
2nd Floor
Coliseum, NYC



3rd Floor
Coliseum, NYC

who's showing what . . .

by exhibitor—page 136
by product—page 154



4th Floor
Coliseum, NYC

who's showing what . . . *by exhibitor*

ACF ELECTRIC DIV, ACF INDUSTRIES. 126
Electrical and electronic components

A-F ENGINEERING 1115
Engineering equipment and services

A'G'A DIV, ELASTIC STOP NUT CORP. OF AMERICA.....2216
Electrical and electronic components

AMP INCORPORATED 1303
Programing systems, switches, multiple aperture devices, electronic assemblies, connectors

APM CORPORATION 915
Special-purpose seals, fasteners, self-grounding power plugs

ACME CHAIN CORPORATION.....413
Circular and other type chains

ACME STEEL COMPANY.....2235
Metal stitchers

ACRO DIV, ROBERTSHAW-FULTON CONTROLS COMPANY 427
Custom-built, precision, snap-action switches, rotary switches, open blade switches

THE ADAMS & WESTLAKE COMPANY 1038
Mercury plunger-type relays

AEROQUIP CORPORATION 1809
Spiral-wrap hose, Teflon hose, quick disconnect couplings, fittings, self-sealing couplings

AETNA BALL & ROLLER BEARING COMPANY 927
Cylindrical roller bearings, standard ball thrust bearings, clutch release bearings

AIRCRAFT & MISSILES MANUFACTURING 928
Magazines

AIR-MAZE CORPORATION 1134
Air filters, exhaust spark arrestors

ALEMITE DIV, STEWART-WARNER CORPORATION 732
Centralized lubrication systems, hydraulic hose lines and fittings

THE LOUIS ALLIS COMPANY.....1712
Transistorized dc drives with dc motors, wound-rotor motors, adjustable ac drives, mechanical belt drives, integral gearmotors, capsular insulated motors

ALLOY PRODUCTS CORPORATION. 1240
Tanks and formed shapes, metal fabricators

ALUMINUM COMPANY OF AMERICA 2032
Selective anodizing, Duotrace pipe, rods, shapes, and welded assemblies, powder metallurgy impacts, expandable tube-in-sheet, prefinished sheet, honeycomb foil, impact extrusions

AMCO ENGINEERING CORP. 337
Electrical and electronic components, instruments

AMERICAN LAUBSCHER CORPORATION 1130
Screw machine parts, springs, spindles and shafts, nameplates and dials, pinions, jewels

AMERICAN NICKELOID COMPANY..2418
Prefinished and preplated metals, vinyl-to-metal laminates, stamped and formed parts

AMERICAN SEALANTS COMPANY..1009
Sealants for locking fasteners

AMERICAN SMELTING AND REFINING COMPANY 904
Materials, shapes and forms

AMPCO METAL, INC. 1612
Sand castings, centrifugal castings, shell mold castings, extruded shapes, sheet, plate, pipe, forgings, machined products

AMPLEX DIV, CHRYSLER CORPORATION 1125
Air bearings, liners for aluminum engine blocks, V-groove pulleys

ANACONDA METAL HOSE DIV, THE AMERICAN BRASS COMPANY....1236
Conduits, vibration eliminators, connectors, wiring

ANCHOR PLASTICS COMPANY, INC 2103
Plastic metal-like molding, extruded thermoplastic moldings, large shapes

APPLIED HYDRAULICS & PNEUMATICS 1111
Magazines

ARCH INSTRUMENT COMPANY.....222
Gear checkers and other precision instruments

ARGUTO OILLESS BEARING COMPANY 525
Pumps, servo gear trains, self-aligning metal-to-plastic bearings, wood-impregnated bearings

ARMCO STEEL CORPORATION.....725
Steel shapes and forms

ARTUS CORPORATION 317
Plastic shims and gaskets

ARVIN INDUSTRIES, INC.....2219
Electrical and electronic components, mechanical parts

ARWOOD CORPORATION 117
Investment castings, ferrous and nonferrous alloys

ASSOCIATED SPRING CORPORATION 1924
Springs, metal stampings, metal fabricators

ATLAS CHAIN & MFG COMPANY..1916
Precision gears, electro-mechanical assemblies, differentials

ATLAS PRECISION PRODUCTS COMPANY 1916
See Atlas Chain & Mfg Co listings

THE AUBURN MFG COMPANY.....1505
High-temperature conductive and shielding gasket materials

AUTOMATIC SWITCH COMPANY...1438
Solenoid valves, electromagnetic controls

AUTOMOTIVE INDUSTRIES 928
Magazines

AVERY LABEL CO, A DIV OF AVERY ADHESIVE PRODUCTS, INC.....535
Mylar-covered printed nameplates and labels, pressure-sensitive metallized panels and nameplates

BARRY CONTROLS INCORPORATED. 1624
Shock and vibration isolators, mounts for sensitive equipment

BATTELLE MEMORIAL INSTITUTE....328
Research and development service

MORRIS BEAN & COMPANY.....220
Electrical and electronic components

BEAVER PRECISION PRODUCTS, INC..236
Ball screw assemblies, ball splines, ball-way cartridge

BEE CHEMICAL COMPANY.....128
Coatings, finishes

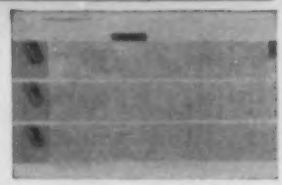
BEEMER ENGINEERING COMPANY. 1127
Powder metal parts, molded rubber parts, molded and machined plastic parts, castings, extrusions

BENDIX COMPUTER DIV, BENDIX AVIATION CORPORATION 121
Computer systems and equipment

BENDIX FOUNDRIES, BENDIX AVIATION CORPORATION 1019
Sand, die, permanent mold, shell mold, centrifugal and plaster mold castings in light alloys

New Design Catalog for Original Equipment Manufacturers Presents the Most Complete Line of Hose and Fittings, Adapters, Self-Sealing Couplings

Hose and Fitting Section—Information on 24 hose types with reusable fittings for pressures up to 5000 psi. for use with hydraulic, air, lube and fuel oils, LP-Gas, water, steam, chemicals and refrigerants.



Adapter Section—O.D. tube and dash sizes are cross-referenced to J. I. C., S. A. E., P. T. T., pipe and straight thread boss (O-ring) ends. Includes 45° and 90° elbows, tees, crosses, union swivels, reducers, bulkhead adapters, caps.

Self-Sealing Coupling Section—Covers variety of standard Self-Sealing Couplings, as well as Aeroquip's ability to adapt couplings to special requirements. Push-pull and screw types, wing or hex nut, mounting flanges.

Hose Assembly Equipment Section—Lists power and hand equipment available to facilitate assembly of Aeroquip Hose and Reusable Fittings.

Design Engineers—here's valuable information to help you solve any fluid piping problem

Your FREE copy of Aeroquip's new 140-page design catalog is ready. Here, in handy form, is the most up-to-date information available to help you save time and money in the design, development and manufacture of fluid systems.

Aeroquip's new fluid system design catalog is divided into four sections; Hose and Fittings, Adapters, Self-Sealing Couplings and Hose Assembly Equipment. Each section contains complete engineering data plus full design information to help you solve just about any fluid piping problem. The catalog is fully illustrated and has complete specifications covering the complete line of products made by Aeroquip for fluid piping systems. Here is comprehensive design information you will want to have at your finger tips at all times—and it's yours free. Just mail the coupon below.

See Aeroquip Products on Display at the Design Engineering Show in New York, May 23-26, Booths 1800 and 1900.

Aeroquip

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DESIGN IN NEW YORK

who's showing what . . .

by exhibitor

BENTON HARBOR ENGINEERING WORKS, INC. 1635
Dual pilot-operated hydraulic check cylinder, flow-control valves

THE BERYLLIUM CORPORATION....342
Beryllium-copper alloys and products

BINKS MANUFACTURING COMPANY.829
Spray gun for plural component materials

BOSTON GEAR WORKS 1808
Helical-geared motorized speed reducers

BOYLE ENGINEERING LABORATORY DIV OF ROTHERM ENGINEERING CO, INC. 2419
Hydraulic and pneumatic parts

W. H. BRADY COMPANY.....1734
Self-bonding nameplates, wire and special markers and wire marking machines, pre-cut masks, printed-circuit tapes

BRAMMER CORPORATION 1440
Adjustable V-link belting and vari-speed belting

BRASS AND BRONZE INGOT INSTITUTE 338
Enginering services

BRIDGEPORT THERMOSTAT DIV, ROBERTSHAW-FULTON CONTROLS COMPANY 425
Bellows and bellow assemblies, thermostats

THE BRISTOL COMPANY.....430
Socket cap screws

BROOK MOTOR CORPORATION....1614
Open drip-proof and totally enclosed fan-cooled ac motors

BROWNING MANUFACTURING COMPANY 2207
V-belts, roller chains, paper pulleys, sheaves, bearing units, couplings, sprockets, spring-loaded variable-pitch sheaves

BRUSH BERYLLIUM COMPANY.....733
Beryllium metal alloys and compounds

BUCHANAN ELECTRICAL PRODUCTS CORPORATION 2216
Cable staples, tools for solderless wire splicing, insulated metallic bushings, connectors, terminal blocks

BURLING INSTRUMENT COMPANY..2100
Temperature controls, thermostats, temperature alarms

CAMLOC FASTENER CORPORATION 1814
Electronic chassis lock, quarter-turn fasteners, quick-release cables and clamps, button fasteners

CANADA, THE DEPARTMENT OF TRADE AND COMMERCE.....1304
Engineering services

CARR FASTENER COMPANY DIV, UNITED-CARR FASTENER CORPORATION 530
Plastic nuts, miniature transistor components, wiring clips, fasteners

CASTING ENGINEERS DIV, CONSOLIDATED FOUNDRIES AND MFG CORPORATION 2334
Investment castings, thin-walled stainless steel castings

CELANESE PLASTICS COMPANY, A DIV OF CELANESE CORPORATION OF AMERICA 1237
Engineering services

CENTURY ELECTRIC COMPANY.....1537
Selective speed drives and gearmotors

CERRO DE PASCO SALES CORPORATION 1204
Low-temperature melting alloys

CHAIN BELT COMPANY 526
Chains, sprockets and bearings for power transmission and conveying

CHART-PAK, INC. 227
Pressure-sensitive tapes and charts

CHEMIQUIP COMPANY 241
Porous pressure snubbers, high-pressure snubbers, mercury traps and desurgers, excess flow-check snubbers

CHEMO PRODUCTS, INC. 124
Engineering services

CHERRY ELECTRICAL PRODUCTS INCORPORATED 1613
Switches of various types

CHICAGO-ALLIS MANUFACTURING CORPORATION 2318
Face-type seals, packings, belts, diaphragms, bellows, pistons

CHILTON COMPANY 928
Magazines

CHROMALLOY CORPORATION OF NEW YORK 135
Chromallized molybdenum, machinable carbides

CIRCLE F MANUFACTURING COMPANY 423
Electrical wiring devices

CLAD-REX DIV OF SIMONIZ CORPORATION 932
Vinyl-clad metals

THE CLEVELAND GRAPHITE BRONZE DIV OF CLEVITE CORPORATION..2204
Sleeve bearings, bushings, thrust washers, shaft seals

CLEVELAND WORM & GEAR DIV, EATON MANUFACTURING COMPANY 1337
Reduction units and variable speed drives

CLIMAX MOLYBDENUM COMPANY, A DIV OF AMERICAN METAL CLIMAX INC 1825
Molybdenum alloys

COATING PRODUCTS, INC.....2013
Metallized Mylar-finished products

COBALT INFORMATION CENTER...2331
Engineering services

COBEHN, INC.....412
Manual and automatic spray-cleaning equipment

COLONIAL RUBBER COMPANY.....934
Industrial rubber, plastic, ceramic products

COLUMBUS COATED FABRICS CORPORATION 533
Vinyl-clad metal

COLUMBUS ELECTRIC MANUFACTURING COMPANY 429
Precision snap-action switches, miniature snap-action switches, polymicro rotary switches

COMMERCIAL FILTERS CORPORATION 504
Metallic and nonmetallic liquid and gas filters, magnetic separators

CONGRESS DRIVES DIV, TANN CORPORATION 1018
Pulleys, V-belts

CONNEAUT RUBBER & PLASTICS COMPANY 934
See Colonial Rubber Co listings

CONOVER-MAST PUBLICATIONS...1225
Magazines

CONTINENTAL-DIAMOND FIBRE CORPORATION 1540
Sheet, plate, shapes

CONTROL DEVICES, MINNEAPOLIS-HONEYWELL REGULATOR COMPANY 1202
Electrical and electronic devices

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For the world's finest reliability

Teeth-jarring circuit vibration a problem? How about searing temperatures, 1000F° plus? Maybe metal-eating salt spray or corona is your circuit nemesis.

No matter what the problem is or where . . . by specifying AMP, you can pick the exact solderless terminal for your requirements from the broadest line on the market—whether you require the great production speed of an AMP Automachine or the small run productivity of an AMP precision hand tool.

In fact when you specify AMP, you pick the surest route of all to consistent, economical circuit reliability. If you want a better way to design and manufacture your circuits, send for the full story on AMP's solderless termination program.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

CIRCLE 139 ON READER SERVICE CARD 139

NEW IDEAS NEW DESIGN IN NEW YORK NEW PRODUCTS

who's showing what . . .

by exhibitor

COOPER ALLOY CORPORATION....300
Stainless steel castings, PH55 castings and bar stock

COORS PORCELAIN COMPANY.....1108
High-alumina ceramic components

COPPER & BRASS RESEARCH ASSOCIATION 529
Nonferrous parts, shapes, forms

CORBIN CABINET LOCK DIV, THE AMERICAN HARDWARE CORPORATION 214
Locks, handles, catches

CORBIN HOSE CLAMP DIV, THE AMERICAN HARDWARE CORPORATION..214
Hose clamps and bands

CORNING GLASS WORKS.....1507
Sealing glass, Pyroceram parts, industrial filter materials, honeycomb materials, fused silica, special products

CRAMER CONTROLS CORPORATION 2333
Timers and timing devices, miniature dc motors

CRANE PACKING COMPANY.....512
Hydraulic packings of Teflon, seals, lapping machines

CRAWFORD FITTING COMPANY....921
Hydraulic and pneumatic components

CULLMAN WHEEL COMPANY.....2225
Sprockets, chains, flexible couplings

CURTISS-WRIGHT CORPORATION, MARQUETTE METAL DIVISION....329
Metals and alloys

THE D. S. D. MANUFACTURING COMPANY 407
Metallic O-rings, quick-disconnnect clamps, gaskets, seals

DAYTON INDUSTRIAL PRODUCTS COMPANY, A DIV OF THE DAYTON RUBBER CO. 1607
Molded products of rubber, rubber-to-metal, rubber-to-fabric

DEARBORN GLASS COMPANY.....431
Glass products, dials

DE LAVAL STEAM TURBINE COMPANY 833
Pumps, compressors, gear drives

DELUXE COILS, INC. 322
Electrical and electronic products, plastic products

DESIGN NEWS 734
Magazines

DETROIT CONTROLS DIV, AMERICAN-STANDARD 1230
Multiple-liquid dispensers, miniature switches, thermostatic actuators

DEUTSCH FASTENER CORPORATION..315
Fasteners

DIAMOND CHAIN COMPANY, INC...424
Steel roller chains, sprockets, flexible shaft couplings

DISOGRIN INDUSTRIES 219
Synthetic rubber products

DIXON CORPORATION 1206
Plastic fabricated parts

DIXON SINTALOY, INC. 2102
Powder-metal gears, inserts, die-castings, molded nylon parts

THE DOBECKMUN COMPANY, A DIV OF DOW CHEMICAL COMPANY 2121
Plastics and plastic products

DODGE MANUFACTURING CORPORATION 1834
Bronze-bushed pillow blocks, V-belt drives, flexible-cushion couplings, dry-fluid drives and couplings, speed reducers, sleeve and antifriction bearings

DOEHLER-JARVIS DIVISION, NATIONAL LEAD COMPANY 2026
Zinc, aluminum, magnesium, copper-base alloy die-castings

DOW CORNING CORPORATION...1915
Silicone paint, molding and laminating resins, dielectric materials, rubber, fluids

DROP FORGING ASSOCIATION.....832
Engineering services

THE INTERNATIONAL NICKEL COMPANY, DUCTILE IRON DIVISION..2000
Metals and alloys

DUFF-NORTON COMPANY 516
Worm-gear jacks

E. I. DU PONT DE NEMOURS & CO., INC
ELASTOMER CHEMICALS DEPT...1409
Synthetic rubber products, foams

FILM DEPT. 1413
Cellulose sponges, polyester film, acetate films

ORCHEM DEPT, FREON DIV.....1502
Fluorinated hydrocarbon refrigerants, propellants, solvents

POLYCHEMICAL DEPT.....1421
Plastic resins

DURAKOOL, INC.....1708
Mercury relays, contactors, switches, metal-to-glass seals, coils, transformers

DURAMETALLIC CORPORATION.....1012
Flexible metallic packings, mechanical seals

DYNAMIC GEAR COMPANY, INC...1104
Miniature, precision, stock and custom gears and differentials, miniature transmission and speed reducers

DZUS FASTENER COMPANY, INC...735
Standard and specialty fasteners

EASTMAN CHEMICAL PRODUCTS, INC
CHEMICAL DIV. 1626
Injection-molded, extruded and vacuum-formed plastic parts

PLASTICS DIV.....2004
Plastic resins

EATON MANUFACTURING COMPANY 1337
Speed reducers, variable speed drives with built-in motors, centralized lubrication

EBERT ELECTRONICS CORPORATION 2217
Mercury plunger relays, sensitive relays

ECLIPSE MACHINE DIV, BENDIX AVIATION CORPORATION 125
Fuel pumps, brakes, motor starter drives, switches

ELASTIC STOP NUT CORPORATION OF AMERICA 2216
Standard and specialty fasteners

ELECTRICAL DESIGN NEWS.....734
Magazines

ELECTRICAL MANUFACTURING.....1225
Magazines

ENGINEERED PLASTICS, INC, AMERICAN SINTERINGS DIV. 1535
Powder metallurgy and plastic molded parts

ENGINEERED PRECISION CASTING COMPANY 909
Investment castings

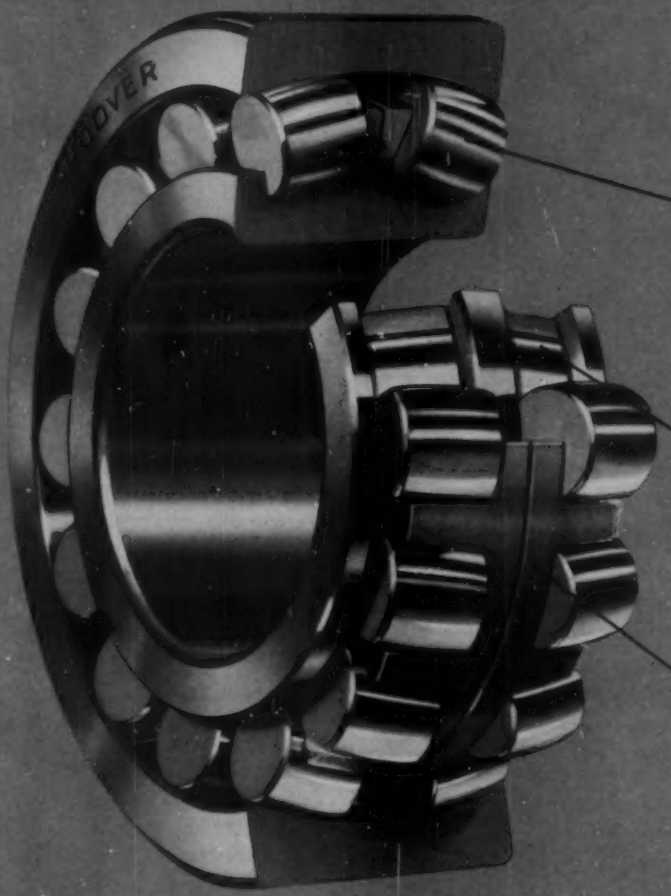
ENJAY COMPANY, INC.....522
Plastic parts

ERIEZ MANUFACTURING COMPANY 1114
Magnetic vibratory feeders, vibrators, magnetic separators

ETHYLENE CORPORATION.....1028
Plastic tubing

hoover quality

...WHAT IT MEANS IN SPHERICAL ROLLER BEARINGS



Super Finish ROLLERS

Super Finish RACEWAYS

MACHINED BRONZE RETAINERS

In spherical roller bearings, *Hoover Quality* means extra smoothness, extra precision, extra bearing performance.

Large size rollers are *Super Finished* to a mirror-like smoothness to minimize friction.

Both inner and outer raceways are *Super Finished* to match the smoothness of the rollers. Precision matching of rollers and raceways assures low operating temperatures and long life.

Land-riding retainers are accurately machined from solid bronze for proper roller guidance and uniform load distribution.

Hoover Quality spherical roller bearings are available in a complete range of sizes and series in cylindrical or tapered bore. Return the coupon below for complete information.

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☐ Have your representative call.

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NEW IDEAS NEW SOURCES
DESIGN IN NEW YORK
NEW PRODUCTS

who's showing what . . .

by exhibitor

FALSTROM COMPANY 1816
Custom cabinets, consoles, chassis, frames, weldments

FARLEY & LOETSCHER MFG CO.....405
Plastic laminates

FARVAL DIVISION, EATON MANUFACTURING COMPANY 1337
Centralized lubrication systems, gear spray lubrication, oil systems

FASSON PRODUCTS 218
Self-adhesive papers, foils, films

FAULTLESS CASTER CORPORATION..2202
Specialty and military casters, industrial wheels and casters

FAWICK AIRFLEX DIVISION, FAWICK CORPORATION 1136
Magnetic brakes

FAY-GARRETTSON, INC.....140
Engineering equipment and services

FENWAL INCORPORATED 1621
Temperature controllers, thermostats

FIBERFIL INC.....919
Nonmetallic materials

FLEXONICS CORPORATION 2421
Hose bellows, expansion joints, compensators, pipe guides

FLORIDA DEVELOPMENT COMMISSION 204
Engineering services

FOOTE BROS GEAR AND MACHINE CORPORATION 828
Helical gear, worm gear, shaft mounted reducers; flexible gear-type couplings

FRANKLIN ELECTRIC CO, INC.....1705
Specialty motors

H. B. FULLER COMPANY.....411
Epoxy structural adhesives, coatings and sealants

GARLOCK PACKING COMPANY....2206
Mechanical packings, gaskets, oil seal, plastic products

E. D. GEOFFREY GARTH AND ASSOCIATES 1031
Nonmetallic materials, shapes and forms

GAST MANUFACTURING CORPORATION 925
Compressors, rotary air motors, vacuum pumps

GENERAL CONTROLS COMPANY...1608
Solenoid valves, counters, switches, controls, electronic components

GENERAL ELECTRIC COMPANY....1724
Limit and drum switches, push buttons, motors and drives

THE GENERAL FIREPROOFING COMPANY 2212
Drawing desks, office desks, chairs

GLASS LABORATORIES, INC.....1107
Metallic plastic moldings, nameplates, micrometers

B. F. GOODRICH AVIATION PRODUCTS, A DIV OF B. F. GOODRICH CO 1403
Rivnuts and installation tools

GRAHAM TRANSMISSIONS, INC.....835
Variable speed transmissions

GRAND SLIDING MECHANISM, INC..312
Mechanical components

GREENE, TWEED & CO.....336
Packings, gaskets, belt couplings

GRIES REPRODUCER CORPORATION 2435
Tiny die-castings and plastic moldings, insulators, bushings, washers, coil bobbins

GROOV-PIN CORPORATION.....2330
Threaded inserts, press-fit pins

HPL MANUFACTURING COMPANY..1022
Stampings from all materials

HAMILTON MANUFACTURING COMPANY 2230
Drawing tables, desks, files

HANDY & HARMAN.....1715
Brazing alloys and fluxes

THE HANSEN MANUFACTURING CO 628
Quick-connect fluid couplings

HARTFORD STEEL BALL COMPANY, INC 1026
Bearings, ball retainers, wheel bearings

JOHN HASSALL, INC.....1639
Cold-headed products

HAYNES STELLITE COMPANY, DIV OF UNION CARBIDE CORPORATION 1408
Metals, ceramics, powders, investment castings

THE HEIM COMPANY.....2113
Bearings, bearing rod ends

HELI-COIL CORPORATION.....1828
Wire thread inserts and inserting tools

HEYMAN MANUFACTURING COMPANY 1217
Nylon snap bushings

THE HILLIARD CORPORATION.....1905
Overrunning, single revolution, centrifugal, slip clutches and clutch couplings, intermittent drive units

HITCHINER MANUFACTURING CO..1231
Precision investment castings

HOKE INCORPORATED.....1536
Various type valves, pressure regulators

HOOVER BALL AND BEARING COMPANY 426
Ball bearings, pillow block bearings

E. F. HOUGHTON & COMPANY....1207
Synthetic packings, wiper rings, retaining rings

HUNGERFORD PLASTICS CORP....1205
Molded plastic parts

HUNTER SPRING COMPANY.....1512
Constant-torque mechanical spring motors, springs, tensile testers

HYDROFORMING COMPANY OF AMERICA, INC.....1634
Drawn metal shapes, deep-drawn rare materials

ILLINOIS TOOL WORKS.....1629
Specialty fasteners

THE IMPERIAL BRASS MANUFACTURING COMPANY.....1606
Pipe and tube fittings, valves, couplings, hose assemblies

INDUSTRIAL EQUIPMENT NEWS...1137
Magazines

THE INDUSTRIAL PUBLISHING CORPORATION 1111
Magazines

INDUSTRIAL RESEARCH.....1625
Magazines

INDUSTRIAL TECTONICS, INC.....1404
Ball and roller bearings

INSTRUMENT SPECIALTIES CO, INC 2426
Beryllium-copper products

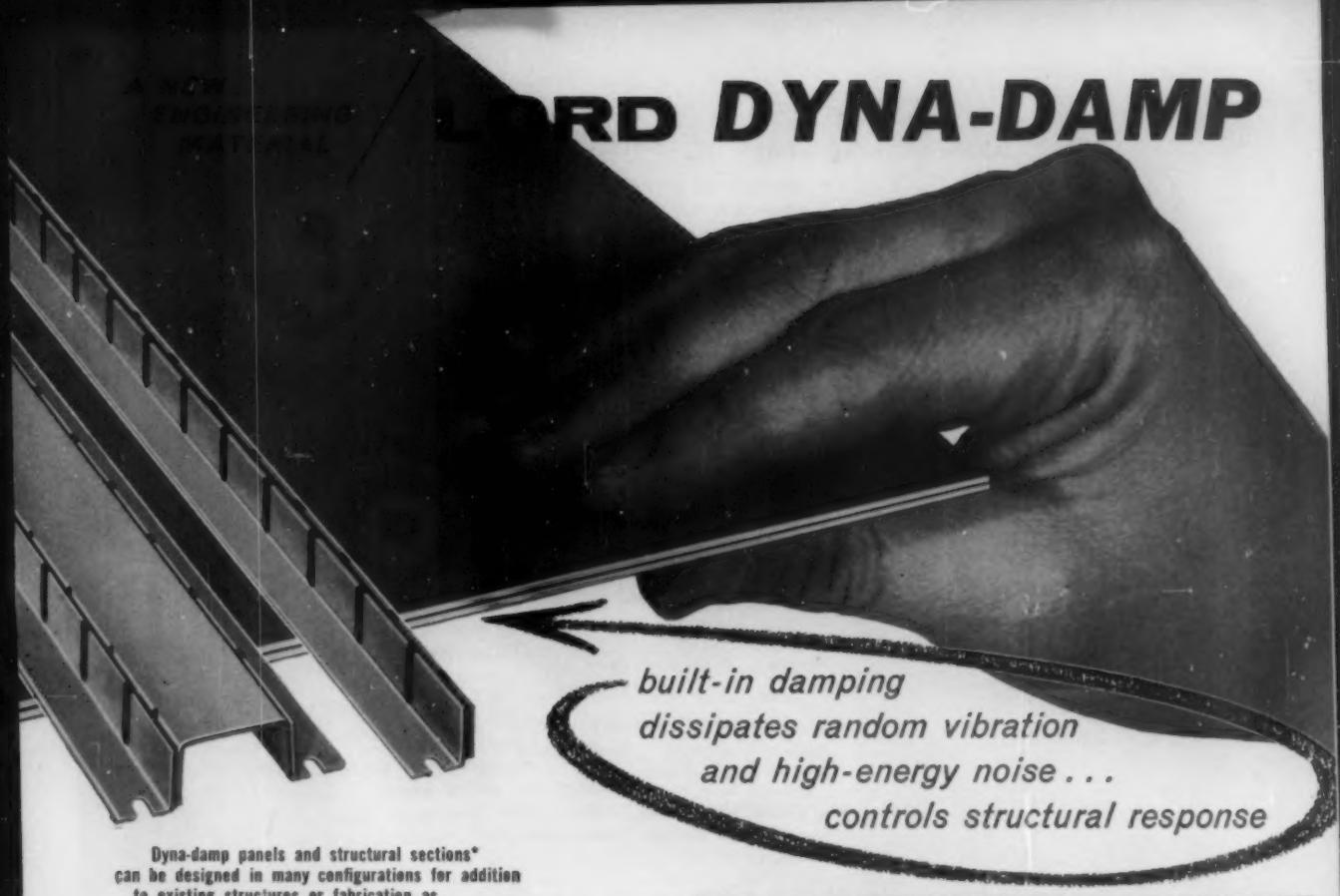
THE INTERNATIONAL NICKEL CO...1815
Nickel and nickel alloys, finishes, coatings

INTERNATIONAL PACKING CORP...1309
Leather and synthetic oil seals, packings, O-rings, special packings

THE IRON AGE.....928
Magazines

JANETTE ELECTRIC MFG CO.....626
Gearmotors, variable speed control equipment, valve drives

LORD DYNA-DAMP



Dyna-damp panels and structural sections* can be designed in many configurations for addition to existing structures or fabrication as complete damped assemblies.

Lord announces Dyna-damp—a new engineering material that counteracts broad-band "white" noise and vibration. It offers a new, better way to solve acoustic fatigue and structural response problems.

Dyna-damp's laminated design converts vibratory energy into shear strains which are dissipated in a highly damped viscoelastic layer. The damping medium is a special form of BTR® elastomer, bonded between metal elements to give structural integrity and load-carrying strength.

In jets, missiles, ships, vehicles, electronic units—wherever control of resonant response is required—Dyna-damp can introduce dramatically improved performance, higher reliability. It is available to industry in sheet and structural sections or in engineered, finished products for use as primary or secondary structures, electronic chassis, complete mounting systems.

Design engineers can obtain further information and able application assistance on Dyna-damp from the nearest Lord Field Engineering Office or the Home Office, Erie, Pennsylvania.

*patent applied for

Radically improved damping is illustrated by typical decay rate traces.

Undamped: 2024 T-3 aluminum panel

Damped: 3-ply Dyna-damp panel

DYNA-DAMP FEATURES

High strength: bonded construction provides structural integrity across complete part. Ultimate strength: 60% of solid aluminum. Shear strength of BTR layer: over 500 psi. Climbing drum peel strength: over 60 lbs.

Light weight: lighter than aluminum sheet of equal thickness.

Excellent fatigue life: proved greatly superior to aluminum in acoustic tests to 170 db.

Broad temperature operation: −65° to + 250°F.

Ease of fabrication: can be punched, sheared or stretch formed by standard methods . . . fastened by riveting or adhesive bonding . . . sections can also be spot welded.

Environmental resistance: good strength and damping ability maintained after 7-day immersion in aircraft fluids.

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA - CEdar 7-9247
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - MIchigan 2-6010
DALLAS, TEXAS - Riverside 1-3392
DAYTON, OHIO - BAldwin 4-0351
DETROIT, MICH. - Diamond 1-4340
KANSAS CITY, MO. - WEstport 1-0133
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
PHILADELPHIA, PA. - PEnnypacker 5-3559
SAN FRANCISCO, CAL. - EXbrook 7-6280
WINTER PARK, FLA. - MIdway 7-5501

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LORD MANUFACTURING COMPANY • ERIE, PA.

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See us at the Design Engineering Show—Booth 1620.

CIRCLE 143 ON READER SERVICE CARD

NEW IDEAS · NEW SOURCES · NEW PRODUCTS
DESIGN IN NEW YORK

who's showing what . . .

by exhibitor

JANNEY CYLINDER COMPANY.....500
Extruded metal shapes, centrifugal castings, special processing

JONES & LAUGHLIN STEEL CORP, STAINLESS AND STRIP DIV.....510
Stainless sheet, strip, bar, wire, zinc and copper-coated tempered spring steel

JOHNSON BRONZE COMPANY....1531
Sleeve bushings and bearings

KAISER ALUMINUM & CHEMICAL SALES, INC.....2005
Aluminum and aluminum alloy

THE KAYDON ENGINEERING CORPORATION 2429
Standard and custom ball, roller and needle bearings

KENNAMETAL INCORPORATED.....1305
Tungsten and tungsten-based carbides, tantalum, manufactured parts

KEYSTONE BOLT AND NUT CORP...401
Standard fasteners

L & L MANUFACTURING COMPANY 1823
Tube and pipe fittings, valves, hydraulic parts

LAMINATED SHIM COMPANY, INC..1221
Surface-bonded and edge-bonded laminated shims, non-laminated shims

THE LAMSON & SESSIONS CO....2002
Standard and specialty fasteners

LANCASTER GLASS CORPORATION 1342
Custom glass parts

LANDIS AND GYR INC.....1830
Electrical impulse and pre-selection counters, miniature ball and roller bearings

LA SALLE STEEL CO.....1321
Cold finished steel bars

LEAD INDUSTRIES ASSOCIATION...632
Nonferrous parts, shapes, forms

LEAR INCORPORATED, INSTRUMENT DIVISION 339
Automatic flight control and stabilization systems and components, electro-mechanical actuating systems

LEE SPRING COMPANY, DIV OF LEETRONICS INC.....1109
Springs, wire forms, stampings

LEHIGH CHEMICAL COMPANY.....1500
Lubricants, oils

LEIMAN BROS, INC.....1630
Vacuum and pressure pumps

LICON DIVISION, ILLINOIS TOOL WORKS 1629
Precision snap-acting switches and related products

LIGNUM VITAE PRODUCTS CORP..2417
Bearings, bushings, wire guides, slides, balls, rollers, pulleys

LINEMASTER SWITCH CORPORATION 1224
Electric foot switches

LINK-BELT COMPANY 2105
Variable-speed drives, parallel-shaft speed reducers

LORD MANUFACTURING COMPANY 1620
Vibration, shock and noise control mountings and mounting systems

LOVEJOY FLEXIBLE COUPLING CO..1504
Flexible couplings, variable-speed pulleys, universal joints

MM ENCLOSURES INC.....2335
Transit and storage cases, metal enclosures

MACHINE DESIGN 1216
Magazines

MAC-IT PARTS COMPANY.....1604
Steel alloy threaded fasteners

MACLEAN-FOGG LOCK NUT COMPANY 1121
Lock nuts, bolts

THE MALAYAN TIN BUREAU.....2430
Engineering services

MARBON CHEMICAL DIVISION, BORG-WARNER CORPORATION...728
Thermoplastic products

MARLANE DEVELOPMENT CO INC..320
Finishes, coatings, engineering services

MARTIN ENGINEERING COMPANY..1903
Vibration inducers

THE MASLAND DURALEATHER CO..1912
Vinyl cladding

MASTER ETCHING CORPORATION..417
Metal nameplates, dials, panels, scales

MATERIALS IN DESIGN ENGINEERING 2125
Magazines

MATTHIESSEN & HEGELER ZINC CO..314
Slab and rolled zinc

MAUREY MANUFACTURING CORPORATION 2317
Sprockets, chain, belts, pulley

MAYLINE COMPANY.....1615
Drafting tables and equipment

McGILL MANUFACTURING CO, INC 1907
Precision ball and roller bearings

MEAD SPECIALTIES COMPANY.....1401
Air cylinders, air-operated clamps, presses, vises, collets

MEASUREMENTS RESEARCH CO....1916
Engineering equipment, services

MECHANICAL RUBBER PRODUCTS CO 309
Mechanical rubber goods, seals, gaskets, tubing, bumpers

MEEHANITE METAL CORPORATION 2226
Materials and castings

METAL FINISHERS INC.....131
Engineering services

METAL POWDER INDUSTRIES FEDERATION 1525
Metal powders, powder metal products

METAL & THERMIT CORPORATION..332
Metals and alloys, organic coatings, thermit welding

MICRO SWITCH DIVISION, MINNEAPOLIS-HONEYWELL REGULATOR CO 1202
Limit, proximity, mercury, toggle, and lighted pushbutton switches

MILLER ELECTRIC COMPANY.....1541
Cord sets, accessories, plugs, connectors

MINNESOTA MINING AND MANUFACTURING CO 1718
Epoxy and thermosetting film adhesives

MOBAY CHEMICAL COMPANY....1129
Urethane foam products, protective coatings, industrial components, polycarbonate molded parts

MOELLER MANUFACTURING COMPANY 313
Adjustable mechanical expansion closures and stoppers

SAMUEL MOORE & COMPANY.....104
Power transmission, nonmetallic parts, hydraulic equipment

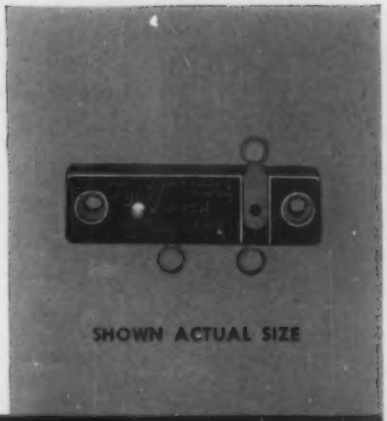
MORSE CHAIN COMPANY, A BORG-WARNER INDUSTRY 1931
Chain, sprockets, couplings, clutches, speed reducers

J. FRANK MOTSON CO.....901
Engineering equipment, services

Think tiny!

DETROIT TyniSwitch

Product designers who want to save space specify Detroit TyniSwitch for precision operation. Class 1 switches measure but 1⅝" by 7/16" by 11/32"—yet provide a full 15 amperes. They stand up under shock and vibration—make and break sharply—are top mounted. A wide variety of actuators and terminals are available. Underwriters' Laboratories listed. Class 4 switches are side mounted and measure 1 13/16" by 7/16" by 17/32".

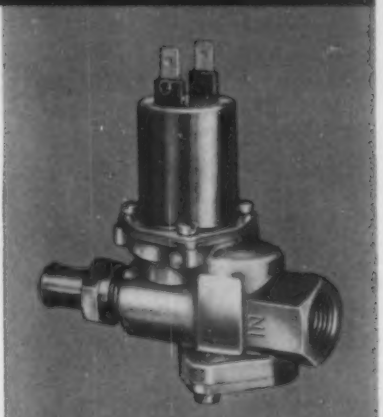


SHOWN ACTUAL SIZE

Think big!

DETROIT Appliance Solenoid Valves

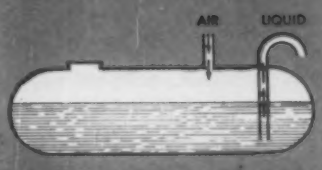
Here is a product that does a king-sized job of controlling water flow regardless of varying supply pressures. It is designed to dependably open and close time after time after time. A wide variety of mounting brackets as well as pipe, tubing or hose connections are available. The valve coils are available with top or side spade terminals or pigtails. Listed by Underwriters' Laboratories.



Think smart!

DETROIT Air-Expansion System

Has been primarily designed for automatic home laundries, but can be used with slight modifications for other applications where accurate amounts of liquid must be dispensed. The system features an air displacement pump of unique and exclusive design. The pump forces air into a liquid reservoir to displace measured amounts of liquids. The liquids never touch any moving parts, eliminating possible fouling. An automatic control in combination with a diverter valve will program the dispensing of desired liquids.



Think Detroit!

When it comes to controls

Write: Detroit Controls, 5900 Trumbull Avenue, Detroit 8, Michigan

American-Standard and Standard ® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard

DETROIT CONTROLS DIVISION

Be Sure To See Detroit Controls At Booth 1230—
Design Engineering Show New York City May 23-26.

who's showing what . . .

by exhibitor

MUELLER BRASS CO.....1405
Brass and copper parts and products

MYCALEX CORPORATION OF AMERICA 1400
High-temperature insulation, mica, switches, tube sockets

NATIONAL BERYLLIA CORPORATION 308
Beryllium oxide electronic accessories, precision ceramics

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION....2104
Mechanical parts, power transmission devices, shapes and forms

NATIONAL VULCANIZED FIBRE COMPANY 1913
Laminated plastics

NEW DEPARTURE DIVISION, GENERAL MOTORS CORPORATION...633
Bearings

NEWARK WIRE CLOTH COMPANY..2233
Wire cloth and fabricated assemblies

NEW ENGLAND LAMINATES CO, INC 1627
Plain and copper-clad plastic and paper-base materials

NEW HERMES ENGRAVING MACHINE CORPORATION 1214
Pantographic engraving machines and accessories

NICAD SEALED CELL, DIV OF GOULD-NATIONAL BATTERIES INC 311
Electrical and electronic equipment

NICE BALL BEARING COMPANY....2321
Ball Bearings, belt and chain idlers, cam followers, wire guides

C. A. NORGREN CO.....918
Air-line filters, pressure regulators, micro-fog lubricators

NYLOK CORPORATION 139
Self-locking bolts, nuts; threaded inserts

THE OHIO KNIFE CO.....929
Wear plates, inserted-type clad slides

OHIO SEAMLESS TUBE DIVISION OF COPPERWELD STEEL COMPANY...629
Electric-welded and seamless steel tubing, fabricated and forged tubing, special shapes

OLIN MATHIESON CHEMICAL CORPORATION, ALUMINUM DIVISION 729
Aluminum sheet, strip, extrusions, electrical wire and cable

O'NEIL-IRWIN MANUFACTURING CO 1402
Punches and dies, punch press, press brake dies

ORANGE ROLLER BEARING CO INC 1636
Roller bearings

O'SULLIVAN RUBBER CORPORATION 2420
Semi-rigid and rigid high-impact plastic products

OWENS-CORNING FIBERGLAS CORPORATION 2015
Reinforced plastic molded parts

OZALID, A DIVISION OF GENERAL ANALINE & FILM CORPORATION 1027
Drafting equipment, supplies, duplicators, photo copy machines

THE PALNUT COMPANY.....306
Lock nuts, lock washers, fasteners

PANDUIT CORPORATION.....409
Plastic wiring duct, cable clamps and ties, cable wrap

PARK NAMEPLATE COMPANY INC..911
Adhesive backed foil nameplates

PARKER-HANNIFIN CORPORATION 1339
Tube and hose fittings, air and hydraulic cylinders, seals, airline filters, regulators, lubricators

PARKER-KALON DIVISION OF GENERAL AMERICAN TRANSPORTATION CORP.....635
Selftapping screws, standard and specialty fasteners

PATRON TRANSMISSION CO INC..1440
Power transmission equipment

PENN ENGINEERING & MANUFACTURING CORPORATION 1023
Miniature, floating, self-locking, and self-clinching fasteners

PENN METAL COMPANY INC.....2416
Expanded metals

PENNSYLVANIA FLUOROCARBON COMPANY, INC.....1032
Teflon extrusions, sleeving flexible tubing, special shapes, forms

PENTON PUBLISHING COMPANY...1216
Magazines

PERMACEL 933
Thread sealants, tapes for insulation and high-temperature, epoxy adhesives

PIC DESIGN CORP, SUBSIDIARY OF BENRUS WATCH COMPANY.....1208
Precision gears, components, breadboards, mechanical components

PLAN HOLD CORPORATION.....1001
Vertical and roll filing equipment, binders

PLASTIC WORLD.....1211
Magazines

POLORON PRODUCTS, INC.....518
Vinyl-to-metal laminate products

POLYGON PLASTIC COMPANY.....230
Plastic extrusions

THE POLYMER CORPORATION.....1513
Plastic parts for mechanical, hydraulic uses, coatings

POOLE FOUNDRY & MACHINE COMPANY 428
Gears, couplings, special machines

H. K. PORTER COMPANY, INC, RIVERSIDE-ALLOY METAL DIV....142
Metals, alloys, shapes

POTTER & BRUMFIELD, DIV OF AMERICAN MACHINE AND FOUNDRY CO 1503
Electromagnetic relays

POWER TRANSMISSION DESIGN..1111
Magazines

PRECISION METAL MOLDING.....1111
Magazines

PRECISION METALSMITH, INC.....231
Precision investment castings

PRECISION SPECIALTIES, INC.....301
Mechanical and electrical parts, engineering services

PRESSCO CASTING AND MFG CORP 1302
Brass and bronze pressure die and permanent mold castings

PRODUCT DESIGN AND DEVELOPMENT 304
Magazines

PRODUCT ENGINEERING.....1524
Magazines

PRUDENTIAL INDUSTRIES, INC....1916
Chains, sprockets, couplings, gears, electromechanical assemblies

PURCHASING NEWS 734
Magazines

RAMSEY CORPORATION 2436
Retaining rings

RANDALL GRAPHITE BEARINGS, INC 914
Midget bearings, pillow blocks, bearing cartridges, brackets, bronze bushings, bronze bars, cored and solid

WOLVERINE

TEMPERS TUBING TO

CUSTOMER REQUIREMENTS

Do your requirements call for commercial copper or copper alloy tubing in a special temper? One perhaps, which will permit tighter bends, withstand expansion or contribute to better workability?

If you do, Wolverine Tube, Division of Calumet & Hecla, Inc., can meet your needs either from its normal range of tempers or, on your request, will temper your tubing to meet your specifications.

Wolverine's normal range of tempers for commercial tubing includes: ***soft annealed*** (.040 mm. grain size min.) ***light annealed*** (.040 mm. grain size max.) ***light drawn*** (36,000-47,000 psi tensile Rockwell 30T, 30-60) ***hard drawn*** (45,000 psi min. tensile) (Rockwell 30T-55 min.), Drawn General Purpose (36,000 psi min. tensile) Rockwell 30T-30 min. Frequent inspections throughout the production process assure that tempers will meet customer requirements.

Before placing your next commercial tubing order talk to your Wolverine sales representative. He can show you the many ways in which Wolverine Tube can help you obtain maximum value for your tubing dollar. Write, too, for a copy of the Commercial Tube Catalog.

WOLVERINE TUBE

DIVISION OF

Calumet & Hecla, Inc.

DEPT. A, 17278 SOUTHFIELD RD., ALLEN PARK, MICH.

Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

J-0050

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA • SALES OFFICES IN PRINCIPAL CITIES

who's showing what . . .

by exhibitor

RAYBESTOS-MANHATTAN, INC.....1810
Mechanical packing and gasket materials, rubber products, friction materials, structural parts, adhesives, sealants, coatings

REED & PRINCE MFG COMPANY...1501
Standard and specialty fasteners

RELIANCE ELECTRIC & ENGINEERING COMPANY 2023
Variable-speed drive systems, ac and dc motors

REPUBLIC STEEL CORPORATION...2131
Stainless steel, titanium, plastic-coated pipe, plastic pipe, fasteners, powders

REVERE COPPER AND BRASS INC..1102
Aluminum, brass and copper mill products, tube-in-strip, welding gun

REYNOLDS METALS COMPANY....1921
Extruded and anodized products

M. H. RHODES, INC.....2231
Time switches, time delay relays, mechanical timing devices

RIEGEL PAPER CORPORATION.....1605
Industrial paper specialties

RIEHLE TESTING MACHINES DIV, AMERICAN MACHINE AND METALS, INC.....232
Testing machines, engineering service

RIGIDIZED METALS CORPORATION 1122
Stainless steel, aluminum, brass, copper, titanium forms

ROBIN PRODUCTS COMPANY.....333
Clips and special fasteners

ROCKWOOD PULLEY MFG CO.....1440
Mechanical components

ROEHLEN ENGRAVING WORKS....1227
Plastic, paper, metal, wood, rubber embossing rolls and plates

ROGERS PUBLISHING COMPANY....734
Magazines

ROGERS PUBLISHING COMPANY, TECHNICAL SERVICE DIV.....334
Engineering Service

ROHM & HAAS COMPANY.....2116
Plastic parts

ROLLER BEARING CO OF AMERICA 1530
Bearings, followers, bushing assemblies

ROLLWAY BEARING COMPANY, INC 419
Cylindrical roller bearings

ROPER HYDRAULICS, INC.....935
Positive displacement pumps

ROSAN INC 1215
Specialty fasteners

ROTHERM ENGINEERING COMPANY, INC 2419
Revolving and expansion joints, air nozzles, 3-passage joints

SKF INDUSTRIES, INC.....1932
Ball and roller bearings, miniature bearings, pillow blocks, journal bearings

SAGINAW STEERING GEAR DIVISION, GENERAL MOTORS CORPORATION 1508
Ball bearing screws and splines

SANDERS ASSOCIATES, INC.....2215
Electrical and electronic parts

A. SCHRADER'S SON, DIVISION OF SCOVILL MFG CO, INC.....1831
Air cylinders, valves, controls

SCREEN PRODUCTS CO.....913
Strainers, screens, filters, fabricated wire cloth and perforated metal products

SCULLY-JONES & COMPANY.....122
Precision metal parts

SEALOL, INC 1340
Mechanical seals, check valves

SHAKEPROOF DIVISION, ILLINOIS TOOL WORKS 1629
Specialty and standard fasteners

SIER-BATH GEAR AND PUMP CO...2031
Flexible-gear couplings, precision gears, screw pumps

SIFCO METACHEMICAL INC 320
Engineering equipment and services

SIGMAMOTOR INC 2315
Tubing pumps, kinetic clamp units

SIMMONS FASTENER CORP.....2434
Specialty locks and fasteners

SIMPLATROL PRODUCTS CORP.....2415
Electrical clutches and brakes, power converters

SKINNER ELECTRIC VALVE DIVISION, THE SKINNER CHUCK CO..1813
Solenoid valves

SNAP-TITE, INC 825
Quick-disconnect couplings

THE SNOW-NABSTEDT GEAR CORP 1709
Small mobile equipment, speed increasers

SOLA ELECTRIC COMPANY, A DIV OF BASIC PRODUCTS CORP 905
Transformers and voltage regulators

SOUTHCO DIVISION, SOUTH CHESTER CORP 1210
Specialty fastening devices, blind rivets

SPACE/AERONAUTICS 1225
Magazines

SPACE COMPONENTS INC 340
Magnetic switches

SPAULDING FIBRE COMPANY, INC 1016
Phenolic and paper epoxy laminates, vulcanized fibers

SPENCER CHEMICAL COMPANY.....624
Nonmetallic materials

SPIROID DIVISION, ILLINOIS TOOL WORKS 1629
Specialty gears

STACOR EQUIPMENT COMPANY...2322
Drafting room furniture, filing cabinets for blueprints

STAHLIN BROS, INC.....2003
Special parts for electrical wiring

STANDARD PRESSED STEEL CO....2124
Specialty and standard fasteners, screws, bolts

STAR EXPANSION INDUSTRIES CORP 1234
Fasteners for metal-to-wood, metal-to-metal, masonry

STERLING PRECISION CORP 2319
Magnetic brakes, clutches, gears

EDWIN B. STIMPSON COMPANY....235
Eyelets, rivets, terminals, washers, stampings

STOKES MOLDED PRODUCTS DIVISION OF THE ELECTRIC STORAGE BATTERY CO 920
Plastics and hard rubber moldings

STOW MANUFACTURING CO.....1011
Flexible shafts, valve controls, geared joints

STRATOFLEX INC 1300
Hose fittings, assemblies, flexible hose

SUPERITE INSTRUMENT CORP 414
Mechanical components

SUPERIOR TUBE COMPANY 2020
Small diameter metal tubing, superalloy tubing

SWEET'S CATALOG SERVICE, DIV OF F. W. DODGE CORP 2130
Engineering service

SYLVANIA ELECTRIC PRODUCTS INC 1521
Plated fine wire, welds, custom-molded plastics, custom-metal stampings

CIRCLE 149 ON READER SERVICE CARD→

first in silicones

Dow Corning

SILICONE NEWS

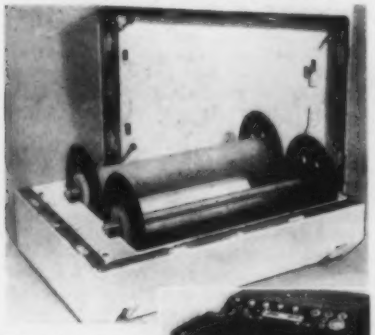
for design and development engineers • No. 74

A FOAMED-IN-PLACE SILICONE PROTECTION

Engineers at Consolidated Electrodynamics Corporation have found a foam-in-place silicone resin ideal for protecting the magazines of oscillographs used to gather vital data during dynamic testing studies of variables affecting aircraft performance.

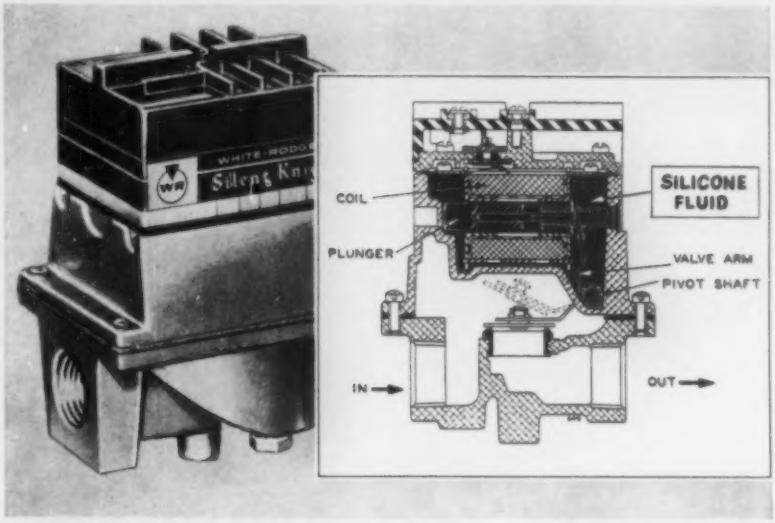
CEC's Recording Oscillographs are capable of simultaneously making permanent, photographic records of up to 50 factors affecting performance. These instruments record information in terms of electric current and catalog all phenomena in true relation to time and to one another.

To be certain that these critical data will be preserved for study through all eventualities, even when experimental aircraft must be ditched, CEC designed and built the first effective crash-resistant storage magazine. The magazine is housed in a ductile-iron casting surrounded by a stainless steel shell. It's protected against heat and shock by a silicone resin foam that fills the space between casting and shell.



Easy to use, the Dow Corning silicone foaming powder is simply poured in place and heated. Heat causes the powder to melt and foam, completely filling the void. Additional protection is provided by painting the outer steel shell with a fire resistant paint that foams at 300 F.

How effective is the Dow Corning silicone foam? CEC estimates the magazine will withstand a shock of 400-g's followed by a fire as hot as 2,000 F! In addition, the magazine is explosion-proofed in accordance with MIL-E-5400 A (ASG). *No. 241*



SILENCES GAS VALVES

Use of silicone fluid has enabled White-Rodgers Company, St. Louis, to produce gas valves that give completely silent service on such units as central heating, floor and wall furnaces, conversion burners, boilers, unit heaters and room circulators. Here's how:

White-Rodgers' engineers effectively eliminated operating noises by immersing the entire operating mechanism of the new Silent Knight Gas Valves in Dow Corning 200 Fluid. Enclosed in an unbreakable metal case, the viscous fluid slows the mechanism, cushions the components and makes them silent. Eliminated are the characteristic "snap" of the relay, the "hammering" of the plunger. In addition, by damping the opening action of the valve, some of the undesirable "pop" of the gas ignition is eliminated.

Silicone fluid proved the ideal damping medium because it doesn't thicken or thin with temperature changes, thus assuring consistent, uniform damping far beyond the capabilities of previously available damping oils. This fluid's noncorrosiveness and resistance to oxidation and to breakdown under shear assures long-time reliable service.

What's more, Dow Corning 200 Fluid's remarkable thermal stability helped simplify the design and increased the reliability of the gas valve by eliminating the need for rubber diaphragms or bellows in the fluid chamber. *No. 242*

New Guide To Silicones In Electronics

First availability. A complete and comprehensive reference guide to the silicone materials that meet exacting electronic requirements.

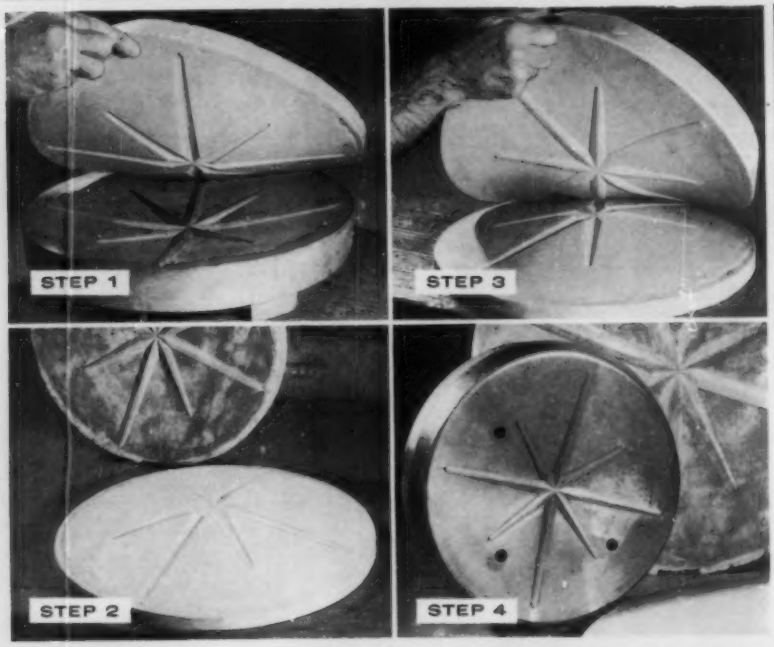
This recently published 12-page engineering guide explains how various physical forms of silicones contribute to reliability, miniaturization, modularization and environmental protection; increase serviceability over wide extremes of temperature; and aid value engineering.

Well illustrated, this new "materials handbook" contains silicone engineering data and processing information . . . details the important electrical and mechanical properties of the silicones most useful in electronics . . . describes typical applications for silicones in every area of use — from satellites to seismographic instruments, from computers to servo motors.

To obtain your free copy, circle—*No. 243*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE OR REFERENCE NUMBER ON READER SERVICE CARD

MORE



HOW TO MAKE PROTOTYPES

Silastic® RTV provides a new and better way to make prototypes. Here's how one automotive parts supplier — Cadillac Stamp Company, Detroit — uses this Dow Corning room-temperature-vulcanizing silicone rubber to make templates for hubcap embossing dies.

STEP 1. Silastic RTV is poured onto a wood pattern machined to the exact configuration of the hubcap design. With its fluid consistency, Silastic RTV flows into and around complex shapes and intricate and deep draws—then vulcanizes at room temperature to produce a strikingly accurate "negative" mold.

STEP 2. A plastic "positive" of the original pattern is then cast in the Silastic RTV mold. This "positive" forms a prototype from which a pantograph-type engraving machine can sink female dies.

STEP 3. Next, more Silastic RTV is poured into the original silicone rubber "negative" mold made of Silastic RTV to form another RTV "positive". After this new charge has vulcanized in the mold the two are separated. Coating the mold with a release agent facilitates clean and quick separation of the new "positive".

STEP 4. A plastic form is now cast from the Silastic RTV "positive". This plastic template is used in guiding the engraving machine in producing male sink dies. In this process, size is reduced by one-half.

An economy feature: Thanks to Silastic RTV both embossing dies are made from one wood original.

For more information, circle . . . *No. 244*

SEE US AT BOOTH 1915

Make it a "must" to stop by . . . for a quick check of the latest developments in the rapidly moving field of silicones . . . .

1960 DESIGN ENGINEERING SHOW — **NEW YORK COLISEUM** MAY 23 - 27

new literature and technical data on silicones

Radiation Stability of Silicone Greases is the subject of an article from Lubrication Engineering. Graphs and illustrations resulting from evidence compiled during an extensive test program point up the degree of radiation stability of silicone fluids. These characteristics help project the utility and stability of silicone greases. A valuable reference piece for advance design and development engineers. *No. 245*

Design Versatility — Lightweight, strong, inert, and easy to fabricate, silicone-glass laminates are used in the design and manufacture of a variety of consumer and industrial products. Applications, tables of physical and dielectric properties, illustrations of various parts, and sources of silicone-glass laminate parts are included in a 4-page brochure. *No. 246*

How To Make Coils more easily . . . and also get better performance . . . is the subject of a compact 8-page booklet reprinted from NISA News. The use of triangular Guideline Tape facilitates and speeds wrapping — provides the good electrical properties, thermal stability, chemical and moisture resistance characteristic of Silastic®, the Dow Corning silicone rubber. This reprint contains helpful graphs, tables, and illustrations. *No. 247*

Wherever There's A Problem — gaskets, seals, O-rings . . . rubber parts fabricated of Silastic, the Dow Corning silicone rubber stay rubbery in spite of heat, cold, compression, weathering or ozone, moisture or steam, oils, fuels, or chemicals that often cause problems. This six-page illustrated brochure cites how these common problems are overcome by the use of Silastic . . . to increase the life and reliability of scores of units while reducing maintenance costs and frequently simplifying design. *No. 248*

You And The Silicones — a new 30-minute, full color movie lets you see silicones in action. It's an all-encompassing, dramatic documentation of designers' adaptations of these versatile engineering materials in different applications. For information about arranging for a free showing, request . . . . . *No. 249*

Designs on the Moon. Created specifically to meet the informational needs of rocket and missile designers, an illustrated brochure describes the finest in silicone materials — rigid, rubbery, fluid and dielectric. Whether you're concerned with nose cones, guidance frames, propulsion, or ground supports, your most rapid progress toward miniaturization, weight reduction, and reliable performance may result from specifying silicone products. *No. 250*

Dow Corning Corporation, Dept. 0605, Midland, Michigan

Please send me: 241 242 243 244 245 246 247 248 249 250

NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE____ STATE_____

SILICONE NEWS is published for design and development engineers by

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.
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VISIT US AT THE
DESIGN SHOW
BOOTH NUMBER 834

created alloys for critical casting requirements...

In less than a decade, Waukesha Foundry Company has created 5 corrosion-resistant, non-galling alloys.

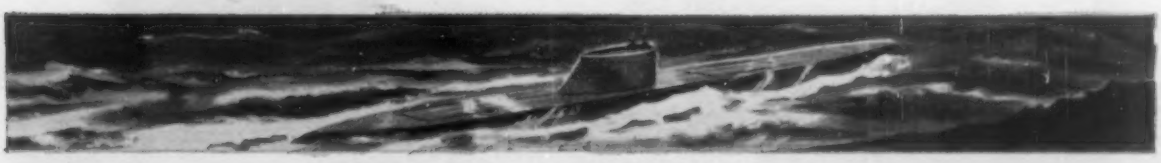
Space vehicles, ships on and beneath the sea, nuclear reactors . . . Waukesha is presently serving these areas where precision engineered castings are an absolute requirement.

Waukesha provides quality "Spectrometer" control with each heat, pilot plant facilities, sand, shell, ceramic-type moldings, and a metallurgical staff with an impressive history in "created metals".

From the blueprint to the finished casting, cousult Waukesha.

Waukesha Foundry Company

Dept. F-5, Waukesha, Wisconsin



NEW IDEAS NEW DESIGN IN NEW YORK NEW PRODUCTS

who's showing what . . .

by exhibitor

SYNTHANE CORP 1126
Laminated plastics

SYNTRON COMPANY 2105
Conveying and feeding devices, dc conversion devices, motors

TANN CORPORATION, CONGRESS DRIVES DIVISION 1018
Power transmisison units

TAYLOR DEVICES, INC 1116
Liquid springs, accumulators

THOMAS FLEXIBLE COUPLING CO..1600
Flexible couplings

THOMAS & BETTS CO, INC 1106
Electrical connectors and fittings

THOMAS PUBLISHING COMPANY..1137
Magazines

F. D. THOMPSON PUBLICATIONS, INC 229
Magazines

THOMSON INDUSTRIES, INC.....2115
Ball bushings, Nylined bearings

JUDSON L. THOMSON MFG CO 625
Rivets and setting machines, electrical contacts and assembly machines

ARTHUR TICKLE ENGINEERING WORKS, INC 1901
Metal spraying, coating, precision work

TINNERMAN PRODUCTS, INC.....1226
Specialty fasteners

TITEFLEX INCORPORATED 408
Mechanical and hydraulic parts, tubing, couplings

TOYAD CORPORATION 1515
Rigid and flexible cellular elastomers

TUBULAR RIVET & STUD CO.....238
Special rivets, rivet setting machines, electrical contacts

UNION CARBIDE CORPORATION..1408
See division listings

UNION CARBIDE METALS CO, DIV OF UNION CARBIDE CORP.....1408
Metals and alloys

UNION CARBIDE PLASTICS CO, DIV OF UNION CARBIDE CORP.....1408
Plastic resins and materials, coatings, films

UNITECH CORPORATION 416
Drafting equipment

UNITED SHOE MACHINERY CORP...924
Metal stampings, rivets and riveting machines

US ELECTRICAL MOTORS INC.....1704
Gearmotors, variable-speed motors, gear reducers, control speed systems, encapsulated windings

UNITED STATES PLYWOOD CORP..1117
Cut-to-shape plywood, special laminated panels

UNITED STATES RUBBER COMPANY
MECHANICAL GOODS DIVISION.1324
ROYALITE DIVISION 1324
Timing belt drives, flexible couplings, V-belt, molded parts

UNITED STATES STEEL CORPORATION 2104
Steel and steel products, shapes, forms

US STONEWARE COMPANY.....934
See Colonial Rubber Co listings

UNIVERSAL CASTINGS CORPORATION 1632
Plaster mold castings

UNIVERSAL DRAFTING MACHINE CORP. 634
Drafting room equipment

VALCOR ENGINEERING CORPORATION 1213
All Teflon solenoid valve, 2- 3- and 4-way pneumatic and hydraulic valves

VANTON PUMP & EQUIPMENT CORP, DIV OF COOPER ALLOY CORP....226
Plastic valves, pumps, fittings

VEEDER-ROOT INCORPORATED ...2316
Mechanical, electromechanical and electronic counting instruments

VIBRO-PLUS PRODUCTS, INC.....2325
Electric vibrators

VICKERS INCORPORATED 1725
Electro-hydraulic controls, pumps, valves, hydraulic assemblies

VIKING PUMP COMPANY.....824
Full-speed pumps, abrasive-liquid pumps, rotary pumps

WALDES KOHINOOR, INC.....2016
Retaining rings, slide fasteners, tools and techniques

JOHN WALDRON CORPORATION..2200
Gear couplings, flexible couplings, overload cutouts

WARNER AUTOMOTIVE DIV, BORG-WARNER CORP. 2213
Gears, gear units, gear boxes

WARNER ELECTRIC BRAKE & CLUTCH CO. 1004
Clutch-pulley drives, fractional and integral hp brakes and clutches

WAUKESHA FOUNDRY COMPANY..834
Nickel-base, nongalling alloys, precision castings

THE WEATHERHEAD COMPANY....1601
Metal tube fittings, hoses and hose ends, screw machine products, swaging machines

WEB CONTROLS CORP.....1729
Torque-control transmissions, air-powered oil-gear brakes, remote actuators, servo controls

WECKESSER COMPANY 1124
Clamps, straps, plastic molder parts, threaded rods

WELDING DESIGN & FABRICATION.1111
Engineering equipment and services

WESTINGHOUSE ELECTRIC CORP...325
Motors and gearmotors

WESTLINE PRODUCTS DIV OF WESTERN LITHOGRAPH COMPANY....2320
Self-adhering, sub-miniature wire markers, preprinted sleeving and tubing

EDWIN L. WIEGAND COMPANY...2336
Electric heaters and elements for industrial processing

WINSMITH, INC. 528
Wormgear speed reducers, helical and planetary reducers, motorized planetary reducers

WITTEK MANUFACTURING CO.....2422
Hose clamps

WOLVERINE TUBE, DIV OF CALUMET & HECLA, INC..... 221
Copper, brass and aluminum tube, extruded aluminum shapes

T. B. WOOD'S SONS COMPANY....1736
Timing belt drives, couplings, motion control sheaves

WOOSTER DIVISION, BORG-WARNER CORPORATION 2213
Hydraulic pumps and electric driven accessories

WORTHINGTON CORPORATION....316
Pumps, all-speed drives, motor drives, motor pulleys

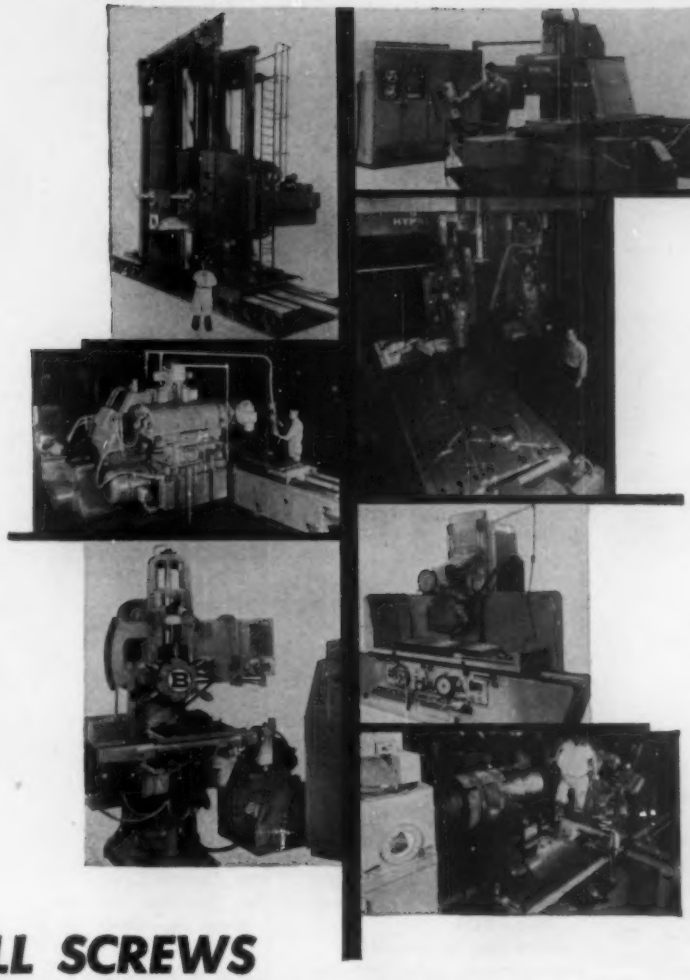
ZENITH ELECTRIC COMPANY.....1241
Automatic transfer switches, magnetic contactors, remote control switches, clocks and timers

THE ZERO-MAX COMPANY, A SUBSIDIARY OF REVCO INCORPORATED.1640
Variable speed drives, overload protectors, overrunning clutches, fractional hp drives

VISIT OUR BOOTH
#236

DESIGN
ENGINEERING
SHOW

NEW YORK
MAY 23-26



BEAVER BALL SCREWS

Part of the Secret of Their High Precision!

Tolerances close as .001" maximum error in 10 feet of ball nut travel are not uncommon in Beaver Ball Screws. Spring rates in excess of 20 million pounds per inch are not exceptional. They're specified where system stiffness that permits accurate locating and repeatability, free from backlash and surge, is essential. 90% (plus) efficiency with consequent low power requirements, compactness and reliability are inherent Beaver characteristics. That's why they are used in actuating vital aircraft parts and head slides and tables of precision machine tools as well as critical functions in other capital equipment.

Beaver Ball Screws provide for the moving of massive loads or extreme small parts such as fuel metering devices with equal sensitivity. Our engineers will be glad to consult with you in determining where they may serve better than hydraulic, pneumatic or acme screw actuation in your product. Write for our catalog.

SPECIFIED BY 22 MAJOR MACHINE TOOL MANUFACTURERS

Largest manufacturers of precision ball screws

Beaver Precision Products INC.
CLAWSON, MICH.

CIRCLE 153 ON READER SERVICE CARD 153

NEW IDEAS NEW SOURCES
DESIGN IN NEW YORK
NEW PRODUCTS

who's showing what . . . *by product*

MECHANICAL COMPONENTS

A. P. M. Corp.—915
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Air-Maze Corp.—1134
Alemite Div., Stewart-Warner Corp.—732
Aluminum Co. of America—2032
Amco Engineering Corp.—337
American Laubscher Corp.—1130
Amplex Div., Chrysler Corp.—1125
Arch Instrument Co.—222
Arguto Oilless Bearing Co.—525
Artus Corp.—317
Arwood Corp.—117
Associated Spring Corp.—1924
Atlas Chain & Mfg. Co.—1916
Atlas Precision Products Co.—1916
The Auburn Manufacturing Co.—1505
Barry Controls, Inc.—1624
Beaver Precision Products, Inc.—236
Beemer Engineering Co.—1127
Binks Manufacturing Co.—829
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Brass & Ingot Institute—338
Bridgeport Thermostat Div, Robertshaw-Fulton Controls Co.—425
Carr Fastener Co. Div, United-Carr Fastener Corp.—530
Chain Belt Co.—526
Chicago-Allis Mfg Corp.—2318
Cleveland Graphite Bronze Co, Div Clevite Corp.—2204
Commercial Filters Corp.—504
Corbin Cabinet Lock Div., The American Hardware Corp.—214
Corbin Hose Clamp Div, The American Hardware Corp.—214
Cramer Controls Corp.—2333
Crane Packing Co.—512
Dayton Rubber Co.—1607
Disogrin Industries—219
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Doehler-Jarvis Div., National Lead Co.—2026
Duff-Norton Co.—516
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Fawick Airflex Div.—1136
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Gries Reproducer Corp.—2435
Hartford Steel Ball Co., Inc.—1026
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Landis & Gyr, Inc.—1830
Lee Spring Co., Div of Leetronics, Inc.—1109
Lignum-Vitae Products Corp.—2417
Link-Belt Co.—2105
Lord Mfg Co.—1620
MM Enclosures Inc., Affiliated with A&P Metal Prods. Mfg—2335
McGill Mfg Co, Inc.—1907
Metal Powder Industries Federation—1525
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Ohio Seamless Tube Div, Copperweld Steel Co.—629
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Raybestos-Manhattan, Inc.—1810
Roller Bearing Co. of America—1530
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Sigmamotor, Inc.—2315
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Spiroid Div., Illinois Tool Works—1629
Sterling Precision Corp.—2319
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Thomson Industries, Inc.—2115
United Shoe Machinery Corp.—924
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Veeder-Root, Inc.—2316
Vibro-Plus Products, Inc.—2325
Warner Automotive Div, Borg-Warner Corp.—2213
Web Controls Corp.—1729
The Zero-Max Co, Sub. of Revco, Inc.—1640

POWER TRANSMISSION EQUIPMENT

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Chicago-Allis Mfg Corp.—2318
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The Cleveland Worm & Gear Co.—1337
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Cullman Wheel Co.—2225
The Dayton Rubber Co.—1607
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Reliance Electric & Engineering Co.—2023
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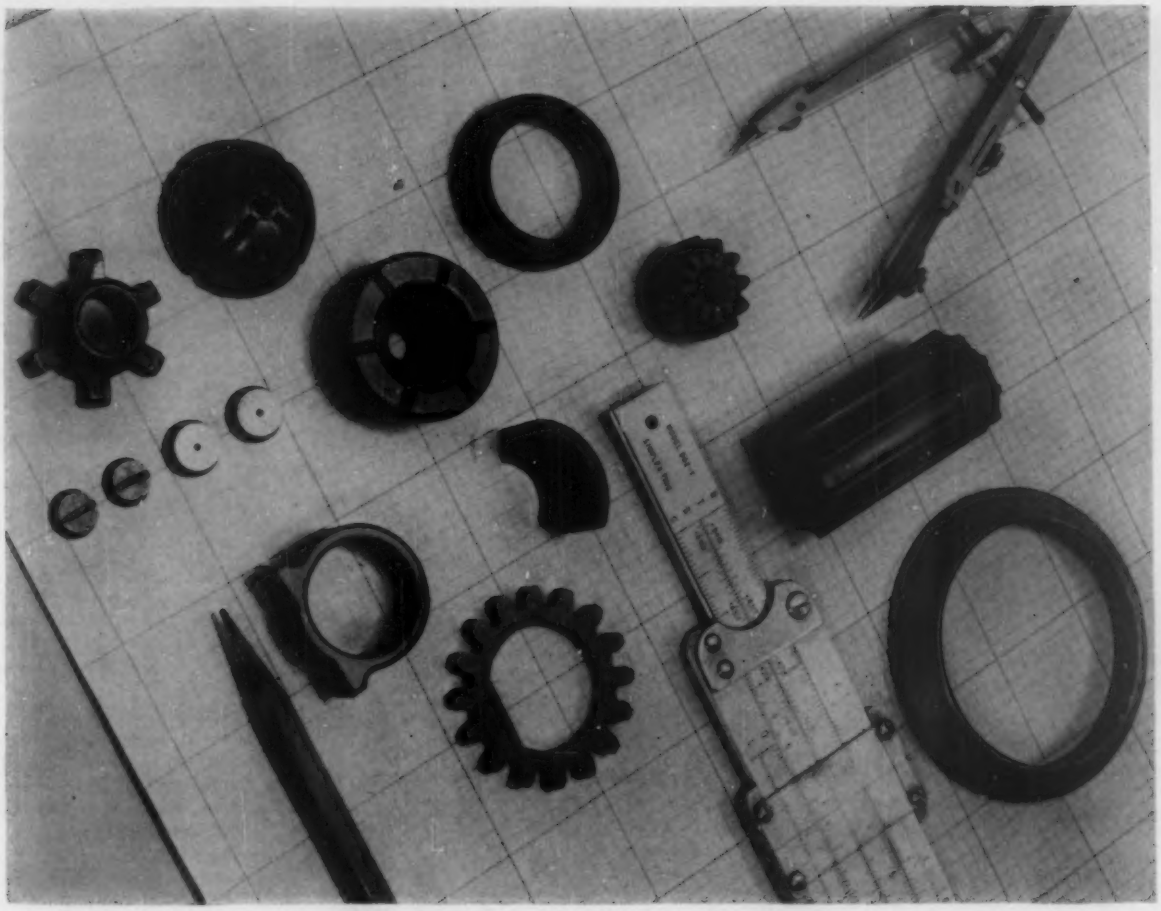
Saginaw Steering Gear Div, General Motors Corp.—1508
A. Schrader's Son, Div Scovill Mfg Co., Inc.—1831
Sealol Corp.—1340
Sier-Bath Gear & Pump Co., Inc.—2031
Sigmamotor, Inc.—2315
Simplatrol Products Corp.—2415
The Snow-Nabstedt Gear Corp.—1709
Sterling Precision Corp.—2319



Need Close Tolerance Parts Like These?

You'll save money if Johnson Bronze makes them for you in Powdered Metals

Making parts like these in powdered metal—quickly, economically and in production tolerances of *.001 of an inch or closer*—is a tradition at Johnson Bronze Co.

That's why Johnson powdered metals—ferrous and non-ferrous—have been in demand for over 20 years. Quality and dollar-conscious engineers know from experience that Johnson powdered metal parts consistently meet material quality and close tolerance requirements.

These engineers also know they can rely on the experience of Johnson's complete product design engineering service. It's one of the many bonuses from using Johnson powdered metal parts. Here's another: *Johnson now can supply powdered metal parts up to 4 inches O.D. and 3 inches long.*

If you need any parts like those shown here, call, write or wire Johnson Bronze Co.

See Us at Booth 1531 at Design Engineering Show

Johnson Bronze Company

New Castle, Pa.

West Coast Plant: Oakland 8, Calif.

CIRCLE 155 ON READER SERVICE CARD 155

DESIGN IN NEW YORK

who's showing what . . .
by product

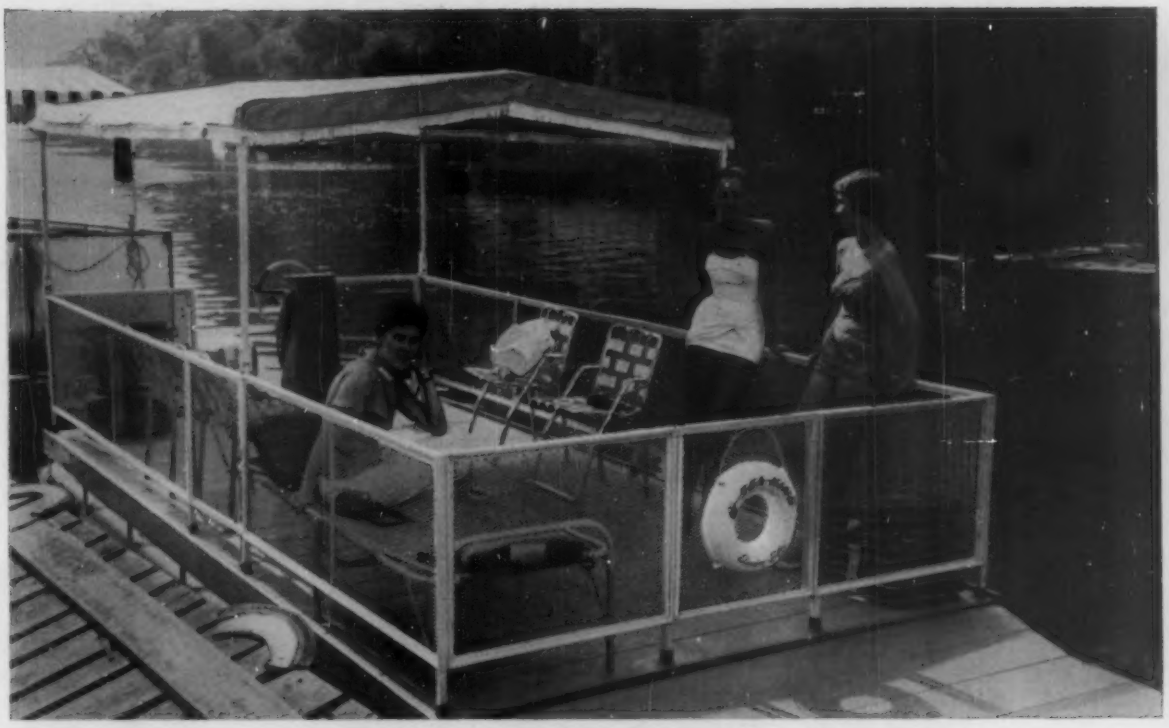
Stow Mfg Co.—1011
Tann Corp., Congress Drives Div.—1018
Thomas Flexible Coupling Co.—1600
United Shoe Machinery Corp.—924
US Electrical Motors, Inc.—1704
US Rubber Co, Mechanical Goods Div.—1324
John Waldron Corp.—2200
Warner Electric Brake & Clutch Co.—1004
Web Controls Corp.—1729
Winsmith, Inc.—528
T B Wood's Sons Co.—1736
Worthington Corp.—316
The Zero-Max Co., Sub. of Revco, Inc.—1640

ELECTRICAL AND ELECTRONIC COMPONENTS

A'G'A Div, Elastic Stop Nut Corp. of America—2216
AMP, Inc.—1303
A. P. M. Corp.—915
Acro Div, Robertshaw-Fulton Controls Co.—427
The Adams & Westlake Co.—1038
The Louis Allis Co.—1712
Aluminum Co. of America—2032
Anaconda Metal Hose Div., The American Brass Co.—1236
Artus Corp.—317
The Auburn Mfg Co.—1505
Automatic Switch Co.—1438
Beemer Engineering Co.—1127
Bendix Computer Div, Bendix Aviation Corp.—121
W. H. Brady Co.—1734
The Bristol Co.—430
Brook Motor Corp.—1614
Brush Beryllium Co.—733
Buchanan Electrical Products Corp.—2216
Burling Instrument Co., Inc.—2100
Carr Fastener Co. Div., United-Carr Fastner Corp.—530
Century Electric Co.—1537
Cherry Electrical Products Corp.—1613
Circle F Mfg Co.—423
Cleveland Graphite Bronze Co, Div. Clevite Corp.—2204
Columbus Electric Mfg Co.—429
Control Devices, Div. Minneapolis-Honeywell Regulator Co.—1202
Coors Porcelain Co.—1108
Corbin Cabinet Lock Div., The American Hardware Corp.—214
Crane Packing Co.—512
Dearborn Glass Co.—431
Deluxe Coils, Inc.—322
Detroit Controls Div, Amer. Radiator & Std. Sanitary Corp.—1230
Dixon Sintaloy, Inc.—2102
The Dobeckmun Co, Div. Dow Chemical Co.—2121
Doehler-Jarvis Div, National Lead Co.—2026
E. I. du Pont de Nemours & Co., Inc., Film Dept.—1413
Durakool, Inc.—1708
Eaton Mfg Co.—1337
Ebert Electronics Corp.—2217
Electro Mechanical Inst. Co.—217
Engineered Plastics, Inc.—1535
Fawick Airflex Div, Fawick Corp.—1136
Fenwal, Inc.—1621
Franklin Electric Co, Inc.—1705
Garlock Packing Co.—2206
General Electric Co.—1724
General Controls Co.—1608
Gries Reproducer Corp.—2435
Heyman Mfg Co.—1217
Illinois Tool Works—1629
Instrument Specialties Co., Inc.—2426
Janette Electric Mfg. Co.—626
Landis & Gyr, Inc.—1830
Lead Industries Associations—632
Lear, Inc., Instrument Div.—339
Lee Spring Co., Div. of Leetronics Inc.—1109
Licon Div, Illinois Tool Works—1629
Linemaster Switch Corp.—1224
Martin Engineering Co.—1903
Micro Switch Div, Minneapolis-Honeywell Regulator Co.—1202
Miller Electric Co.—1541
Mobay Chemical Co.—1129
Mueller Brass Co.—1405
Mycalex Corp. of America—1400
National Beryllia Corp.—308
National Tube Div., United States Steel Corp.—2104
New Departure Div., General Motors Corp.—633
Nicad Sealed Cell, Div. of Gould—National Batteries, Inc.—311
Panduit Corp.—409
Permacel—933
Pic Design Corp, Sub. of Benrus Watch Co., Inc.—1208
The Polymer Corp.—1513
Potter & Brumfield, Div. AMF Co.—1503
Pressco Casting and Mfg Corp.—1302
Ramsey Corp.—2436
Randall Graphite Bearings, Inc.—914
Reliance Electric & Engineering Co.—2023
Reynolds Metals Co.—1921
M. H. Rhodes, Inc.—2231
Riehle Testing Machine Div., American Machine & Metals, Inc.—232
Sanders Associates, Inc.—2215
Simplatrol Products Corp.—2415
Sola Electric Co., Div. Basic Products Corp.—905
Space Components, Inc.—340
Stahlin Brothers, Inc.—2003
Sterling Precision Corp.—2319
Stokes Molded Prods., Div. Electric Storage Battery Co.,—920
Sylvania Electric Products, Inc.—1521
Syntron Co.—2105
Thomas & Betts Co, Inc.—1106
Titeflex Inc.—408
United Shoe Machinery Corp.—924
US Electrical Motors, Inc.—1704
Veeder-Root, Inc.—2316
Vibro-Plus Products, Inc.—2325
Warner Electric Brake & Clutch Co.—1004
Web Controls, Corp.—1729
Weckesser Co.—1124
Westinghouse Electric Corp.—325
Westline Products Div., Western Lithograph Co.—2320
Edwin I. Wiegand Co.—2336
Zenith Electric Co.—1241
Zero-Max Co., Sub. of Revco Inc.—1640

METALS

Acme Steel Co.—2235
Aluminum Co. of America—2032
American Nickeloid Co.—2418
American Smelting & Refining Co.—904
Ampco Metal, Inc.—1612
Armco Steel Corp.—725
Arvin Industries, Inc.—2219
Bendix Foundries, Bendix Aviation Corp.—1019
The Beryllium Corp.—342
Brass & Bronze Ingot Institute—338
Brush Beryllium Co.—733
Cerro de Pasco Sales Corp.—1204
Clad-Rex Div. Simoniz Co.—932
Cleveland Graphite Bronze Co., Div. Clevite Corp.—2204
Climax Molybdenum Co., Div. American Metal Climax, Inc.—1825
Cobalt Information Center—2331
Cooper Alloy Corp.—300
Copper & Brass Research Association—529
Curtiss-Wright Corp., Marquette Metal Div.—329
Dearborn Glass Co.—431
Doehler-Jarvis Div, National Lead Co.—2026
Drop Forging Association—832
Eaton Mfg. Co.—1337
Engineered Precision Casting Co.—909
Flexonics Corp.—2421
Handy & Harman—1715
Haynes Stellite Co, Div. Union Carbide Corp.—1408
International Nickel Co., Inc.,—1815
Janney Cylinder Co.—500
Jones & Laughlin Steel Corp., Stainless and Strip Div.—510
Johnson Bronze Co.—1531
Kaiser Aluminum & Chemical Sales, Inc.—2005
Kennametal, Inc.—1305
Laminated Shim Company, Inc.—1221
La Salle Steel Co.—1321
Lead Industries Association—632
Malayan Tin Bureau—2430
Master Etching Corp.—417
Matthiessen & Hegeler Zinc Co.—314
Meehanite Metal Corp.—2226
Metal Powder Industries Federation—1525
Mueller Brass Co.—1405
New Departure Div, General Motors Corp.—633
Newark Wire Cloth Co.—2233
The Ohio Knife Co.—929
Ohio Seamless Tube Div, Copperweld Steel Co.—629
Olin Mathieson Chemical Corp.—729
O'Neil-Irwin Mfg Co.—1402
Penn Metal Co, Inc.—2416
Poloron Products, Inc.—518
H. K. Porter Co., Inc., Riverside-Alloy Metal Div.—142
Pressco Casting & Mfg Corp.—1302
Randall Graphite Bearings, Inc.—914
Republic Steel Corp.—2131
Revere Copper & Brass, Inc.—1102
Reynolds Metals Co.—1921



Penmetal expanded metal helps you sail with security on this versatile pontoon boat

In designing and building the "Twin-Flo" pontoon boat, Modern Welding Company has placed the emphasis on comfort . . . and safety. That is why Penmetal expanded metal was chosen for the railings and gates.

Strong, yet light in weight, this diamond mesh provides superior security for those on board, without adding significantly to the over-all weight of the vessel. Expanded metal has the rigidity to span large areas in an unbroken sweep; the stamina to withstand the abuse of every day use. What's more, it adds much in the way of appearance, having that simple, functional look typical of good modern design.

Perhaps one or all of the qualities mentioned above can be applied to your product through the use of Penmetal expanded metal. Catalog 521-EM will help you select it. Send for a copy today.

Comfort and safety afloat, by Modern Welding Company, Owensboro, Kentucky.

PENN METAL COMPANY, INC.

Expanded Metal Sales Office: P.O. Box 1460, Parkersburg, W. Va.

Executive Offices: 40 Central Street, Boston 9, Mass.

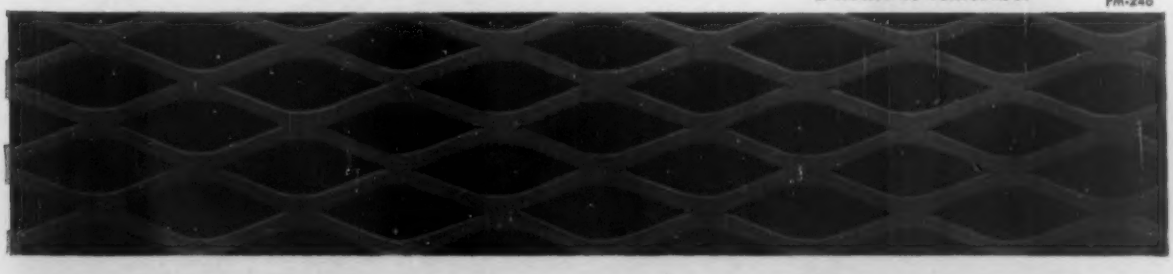
Plant: Parkersburg, W. Va.

District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg, St. Louis

METAL MARK Penmetal 1869 OF QUALITY

a name to remember

PM-246



CIRCLE 157 ON READER SERVICE CARD

ANNOUNCING A NEW CORPORATE NAME

for The Garlock Packing Company

Garlock Inc. becomes the new name for The Garlock Packing Company, Palmyra, N. Y., to reflect more accurately its broad diversification of products and markets.

Originally established to manufacture mechanical packings, Garlock now produces over 2,000 different styles of packings, gaskets, seals, molded and extruded rubber and plastic products for every major industry.

The new corporate name, Garlock Inc., more closely identifies this 73-year-old company with the growth and development of its product lines. *Today, industry goes to Garlock for such widely diversified products as:*

- Hydraulic-Pneumatic Packings
- Oil and Grease Seals
- Gasketing and Expansion Joints
- Braided Packings
- Molded and Extruded Rubber Parts
- Plastic Stock Shapes and Fabricated Parts
- Mechanical Seals for Rotating Shafts
- Metal Packings
- Leather Packings
- Electronic Components
- Dry Bearing Materials
- Fluorocarbon Tank Linings
- Missile and Rocket Components

To help you in selecting or applying these products, Garlock offers the services of over 126 thoroughly-trained sales engineers, 175 electronic component manufacturers' representatives, 180 authorized bearing distributors and 69 foreign distributors. Conveniently located warehouses and stocking points assure Garlock customers of prompt delivery.

At Garlock Inc., design and development of new or improved products and materials is an ever-present objective. To this end Garlock maintains extensive research and laboratory-test facilities. In addition, Garlock engineers and chemists are always ready to work with you in seeking solutions to tough application problems.

GARLOCK

To find out more about "the new Garlock," call the nearest of our 26 sales offices, or write to Garlock Inc., Palmyra, N. Y. *To assure prompt attention,* please refer to *Garlock Inc.* on all future correspondence and orders.

Canadian Div.: Garlock of Canada Ltd.

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

Hydraulic-Pneumatic Packings

Expansion Joints

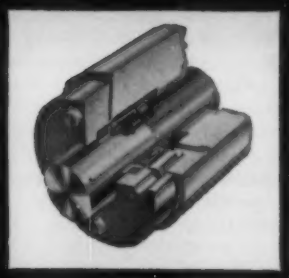
Molded and Extruded Rubber Parts

Plastic Stock Shapes and Fabricated Parts

Braided Packings

Fluorocarbon Tank Linings

Oil and Grease Seals



Mechanical Shaft Seals

Gasketing

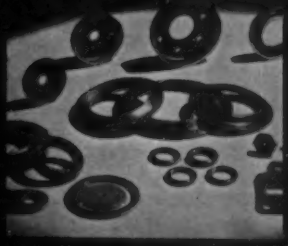
Spiral Wound Gaskets

Metal Packings

Dry Bearing Material

INC.

Missile and Rocket Components



Leather Packings

Electronic Components

who's showing what . . . *by product*

Rigidized Metals Corp.—1122
Superior Tube Co.—2020
Arthur Tickle Engineering Works, Inc.—1901
Union Carbide Corp.—1408
US Steel Corp.—2104
Universal Castings Corp.—1632
Waukesha Foundry Co.—834
Wolverine Tube Div, Calumet & Hecla, Inc.—221

NONMETALLIC MATERIALS

American Smelting & Refining Co.—904
Anchor Plastics Co, Inc.—2103
The Auburn Mfg Co.—1505
Avery Label Co., Div. of Avery Adhesive Products, Inc.—535
Celanese Plastics Co, Div Celanese Corp.—1237
Chicago-Allis Mfg Corp.—2318
Colonial Rubber Co., US Stoneware Corp.—934
Columbus Coated Fabrics Corp.—533
Continental - Diamond Fibre Corp.—1540
Coors Porcelain Co.—1108
Corning Glass Works—1507
Crane Packing Co.—512
Disorgrin Industries—219
Dixon Corp.—1206
Dobeckman Co, Div. Dow Chemical Co.—2121
Dow Corning Corp.—1915
E I du Pont De Nemours & Co, Inc.
Elastomer Chemicals Dept.—1409
Polychemicals Dept.—1421
Orchem Dept—Freon Div.—1502
Eastman Chemical Products, Inc., Plastics Div.—2004
Enjay Co, Inc.—522, 524
Ethylene Corp.—1028
Farley & Loetscher Mfg Co.—405
Farval Div., Eaton Mfg Co.—1337
Fasson Products—218
Fiberfil, Inc.—919
Garlock Packing Co.—2206
E. D. Geoffrey Garth & Associates—1031
Glass Laboratories, Inc.—1107
Hungerford Plastics Corp.—1205
Lancaster Glass Corp.—1342
Lead Industries Association—632
Lehigh Chemical Co.—1500
Lignum-Vitae Products Corp.—2417
Marbon Chemical Div, Borg-Warner Corp.—728
The Masland Duraleather Co.—1912
Mechanical Rubber Products Co.—309
Mobay Chemical Co.—1129
Mycalex Corp. of America—1400
National Beryllia Corp.—308
National Vulcanized Fibre Co.—1913
New England Laminates Co, Inc.—1627
O'Sullivan Rubber Corp.—2420
Pennsylvania Fluorocarbon Co, Inc.—1032
Permacel—933
Polygon Plastic Co.—230
The Polymer Corp.—1513
Raybestos-Manhattan, Inc. —1810
Rohm & Haas Co.—2116
Spaulding Fibre Co, Inc.—1016
Spencer Chemical Co.—624
Stokes Molded Prods, Div. Elec. Storage Battery Co.—920
Synthane Corp.—1126
Toyad Corp.—1515
Union Carbide Corp.—1408
Union Carbide Plastics Co, Div Union Carbide Corp.—1408
US Plywood Corp.—1117
US Rubber Co,
Mechanical Goods Div.—1324
Royalite Div.—1324
US Steel Corp.—2104
US Stoneware Co.—934
Westline Prods Div., Western Lithograph Co.—2320

FASTENERS AND ADHESIVES

AMP Inc.—1303
A. P. M. Corp.—915
Acme Steel Co.—2235
Aluminum Co. of America—2032
American Sealants Co.—1009
Ampco Metal, Inc.—1612
The Auburn Mfg Co.—1505
Avery Label Co., Div. Avery Adhesive Products, Inc.—535
The Bristol Co.—430
Camloc Fastener Corp.—1814
Carr-Fastener Co, Div United-Carr Fastener Corp.—530
Corbin Cabinet Lock Div, Amer. Hardware Corp.—214
Corbin Hose Clamp Div, American Hardware Corp.—214
Deutsch Fastener Corp.—315
Dzus Fastener Co, Inc.—735
Eastman Chemical Products, Inc., Chemicals Div.—1626
Eaton Mfg Co.—1337
Elastic Stop Nut Corp of America—2216
H. B. Fuller Co.—411
E. D. Geoffrey Garth & Associates—1031
BF Goodrich Aviation Prods, Div. BF Goodrich Co.—1403
Gries Reproducer Corp.—2435
Groov-Pin Corp.—2330
John Hassall, Inc.—1639
Heli-Coil Corp.—1828
Illinois Tool Works—1629
Keystone Bolt & Nut Corp.—401
The Lamson & Sessions Co.—2002
Lee Spring Co., Div. of Leetronics, Inc.—1109
Mac-It Parts Co.—1604
MacLean-Fogg Lock Nut Co.—1121
Minnesota Minning & Mfg Co.—1718
Mobay Chemical Co.—1129
Moeller Mfg. Co.—313
Samuel Moore Co., Borg-Warner Industry—1931
Nylok Corp.—139
The Palnut Co.—306
Parker-Kalon Div, Gen. Amer. Transportation Corp.—635
Penn Engineering & Mfg Corp.—1023
Permacel—933
Ramsey Corp, Sub. Thompson Products, Inc.—2436
Raybestos-Manhattan, Inc. —1810
Reed & Prince Mfg Co.—1501
Robin Products Co.—333
Rosan, Inc.—1215
Shakeproof Div, Illinois Tool Works—1629
Simmons Fastener Corp.—2434
Southco Div, South Chester Corp.—1210
Standard Pressed Steel Co.—2124
Star Expansion Industries Corp.—1234
Judson L Thomson Mfg Co.—625
Tinnerman Products, Inc.—1226
Tubular Rivet & Stud Co.—238
United Shoe Machinery Corp.—924
Waldes Kohinoor Inc, Truarc Retaining Rings Div.—2016
Weckesser Co.—1124
Wittek Mfg Co.—2422

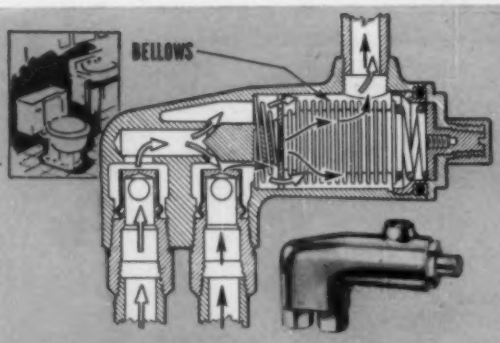
FINISHES AND COATINGS

Aluminum Co. of America—2032
American Nickeloid Co.—2418
American Smelting & Refining Co.—904
Arvin Industries—2219
Avery Label Co, Decorative Prods. Dept.—535
Bee Chemical Co, Logo Div.—128
Chemo Products Inc.—124
Chromalloy Corp. of New York—135
Clad-Rex Div. Simoniz Co.—932
Coating Products Inc.—2013
Columbus Coated Fabrics Corp.—533
Dobeckmun Co, Div. Dow Chemical Co.—2121
Doehler-Jarvis Div, National Lead Co.——2026
Lead Industries Association—632
Marlane Development Co, Inc.—320
The Masland Duraleather Co.—1912
Metal & Thermit Corp.—332
Mobay Chemical Co.—1129
Permacel—933
Poloron Products Inc.—518
The Polymer Corp.—1513
Rigidized Metals Corp.—1122
Roehlen Engraving Works—1227
Sifco Metachemicals, Inc.—320
Arthur Tickle Engineering Works, Inc.—1901
United Shoe Machinery Corp.—924
US Stoneware Co.—934

SHAPES AND FORMS

Alloy Products Corp.—1240
Aluminum Co. of America—2032
American Smelting & Refining Co.—904
Ampco Metal, Inc.—1612
Anchor Plastics Co, Inc.—2103
Arvin Industries, Inc,—2219
The Auburn Mfg Co.—1505
Morris Bean & Co.—220
Beemer Engineering Co.—1127
Casting Engineers Div., Consolidated Foundries and Mfg. Corp.—2334
Chemo Products, Inc.—124
Chicago-Allis Mfg Co.—2318
Colonial Rubber Co.—934
Conneaut Rubber & Plastics Co.—934
Continental-Diamond Fibre Corp.—1540
Copper & Brass Research Association—529
Dearborn Glass Co.—431

DESIGN FOR BEST PERFORMANCE, LOW COST with Flexonics BELLOWS

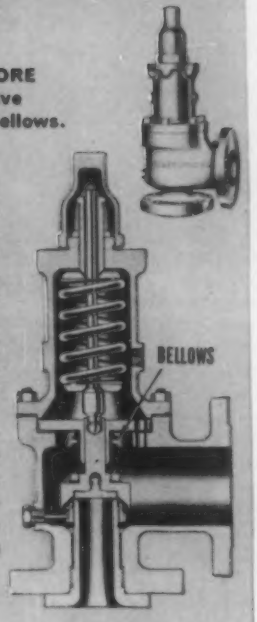


KOHLER of KOHLER eliminates closet condensation with thermostatic supply valve.

A Flexonics bronze bellows is the heart of the new Kohler thermostatic valve designed to mix water from the hot and cold lines to deliver tempered water to the closet tank . . . eliminating annoying condensation (sweating). The fast response of the bellows keeps water in perfect temperature balance . . . automatically. Valve requires no adjustment for seasonal variations in water temperature. Another example of the adaptability of Flexonics bellows in designing for best performance at low cost.

MANNING, MAXWELL & MOORE Consolidated Safety Relief Valve features FLEXONICS sealing bellows.

After long investigation and literally thousands of tests, a Flexonics stainless steel, two-ply bellows was selected for the Consolidated Safety Relief Valve. The bellows isolates contaminants, corrosion, or viscous fluids from the working parts of the valve. It is designed to allow a maximum variation in back pressure at the valve outlet while at the same time maintaining the important characteristics of high capacity, no change in set pressure, and limited blowdown changes.



For design applications that involve the measurement of pressure or temperature... a flexible sealer... or even low-torque power transmission – a Flexonics Bellows can be your answer. Send an outline of your bellows application – the Flexonics Application Engineering Staff will be pleased to make recommendations. If you prefer *write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.*

B-600

Flexonics corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

EXPANSION JOINTS · METAL HOSE · SYNTHETIC HOSE · BELLOWS · AERO/SPACE COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY!

FLEXONICS CORPORATION
1351 South Third Avenue
Maywood, Illinois

Please send my personal copy of Flexonics 20 page Bellows Design Guide covering in detail Flexonics products and services for bellows applications.

CIRCLE 161 ON READER SERVICE CARD 161

who's showing what . . .

by product

Disogrin Industries—219
Dixon Sintaloy, Inc.—2102
Doehler-Jarvis Div, National Lead Co.—2026
Drop Forging Association—832
Ductile Iron Div, International Nickel Co, Inc.—2000
Engineered Plastics Inc.—1535
Falstrom Co.—1816
Flexonics Corp.—2421
Garlock Packing Co.—2206
E. D. Geoffrey Garth & Associates—1031
Glass Laboratories, Inc.—1107
Gries Reproducer Corp.—2435
HPL Mfg Co.—1022
Haynes Stellite Co., Div Union Carbide Corp.—1408
Hitchner Mfg Co, Inc.—1231
Hunter Spring Co.—1512
Hydroforming Co. of America, Inc.—1634
Janney Cylinder Co.—500
Laminated Shim Co. Inc.—1221
Lignum-Vitae Products Corp.—2417
MM Enclosures Inc, Affiliated With A&P Metal Prods, Mfg. Corp.—2335
Meehanite Metal Corp.—2226
Metal Powder Industries Federation—1525
Mobay Chemical Co.—1129
Mueller Brass Co.—1405
National Beryllia Corp.—308
National Tube Div, US Steel—2104
Ohio Seamless Tube Div, Copperweld Steel Co.—629
O'Sullivan Rubber Co.—2420
Pennsylvania Fluorocarbon Co, Inc.—1032
The Polymer Corp.—1513
Precision Metalsmith, Inc.—231
Pressco Casting & Mfg Corp.—1302
Raybestos-Manhattan, Inc.—1810
Roehlen Engraving Works—1227
Edwin B. Stimpson Co.—235
Stokes Molded Prods, Div. Electric Storage Battery Co.—920
Superior Tube Co.—2020
Toyad Corp.—1515
Union Carbide Corp.—1408
US Rubber Co, Mechanical Goods Div.—1324
US Rubber Co, Royalite Div.—1324

HYDRAULIC AND PNEUMATIC COMPONENTS

Aeroquip Corp.—1809
Air-Maze Corp.—1134
Alemite Div, Stewart-Warner Corp.—732
Aluminum Co. of America—2032
Anaconda Metal Hose Div, American Brass Co.—1236
Artus Corp.—317
The Auburn Mfg Co.—1505
Automatic Switch Co.—1438
Beemer Engineering Co.—1127
Benton Harbor Engineering Works, Inc.—1635
Boyle Engineering Lab Div. Rotherm Engrg Co, Inc.—2419
Bridgeport Thermostat Div, Robertshaw-Fulton Controls Co.—425
Chemiquip Co.—241
Chicago-Allis Mfg Corp.—2318
Cleveland Graphite Bronze Co, Div Clevite Corp.—2204
Commercial Filters Corp.—504
Control Devices, Div. Minneapolis-Honeywell Regulator Co.—1202
Crane Packing Co.—512
Crawford Fitting Co.—921
D.S.D. Mfg. Co.—407
De Laval Steam Turbine Co.—833
Disogrin Industries—219
Eclipse Machine Div., Bendix Aviation Corp.—125
Engineered Plastics Inc.—1535
Flexonics Corp.—2421
Garlock Packing Co.—2206
Gast Mfg Corp.—925
General Controls Co.—1608
Greene, Tweed & Co.—336
The Hansen Mfg Co.—628
The Heim Co.—2113
Hoke, Inc.—1536
E. F. Houghton & Co.—1207
The Imperial Brass Mfg Co.—1606
International Packings Corp. 1309
Janney Cylinder Co.—500
L & L Mfg Co.—1823
Lear, Inc., Instrument Div.—339
Leiman Brothers, Inc.—1630
Martin Engineering Co.—1903
Mead Specialties Co.—1401
Mobay Chemical Co.—1129
Mueller Brass Co.—1405
New Departure Div, General Motors Corp.—633
C. A. Norgren Co.—918
Parker-Hannifin Corp.—1339
Pic Design Corp, Sub. Benrus Watch Co, Inc.—1208
The Polymer Corp.—1513
Ramsey Corp.—2436
Raybestos-Manhattan, Inc.—1810
Roller Bearing Co of America—1530
Roper Hydraulics, Inc.—935
Rotherm Engineering Co, Inc.—2419
Sanders Assoc., Inc.—2215
A Schrader's Son, Div Scovill Mfg Co, Inc.—1831
Screen Products Co.—913
Sealol Corp.—1340
Sigamotor, Inc.—2315
Skinner Electric Valve Div, Skinner Chuck Co.—1813
Snap-Tite, Inc.—825
Stokes Molded Prods, Div. Electric Storage Battery Co.—920
Stratoflex, Inc.—1300
Taylor Devices, Inc.—1116
Titeflex, Inc.—408
Valcor Engineering Corp.—1213
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Unitech Corp.—416
United Shoe Machinery Corp.—924
Universal Drafting Machine Corp.—634
Vibro-Plus Products, Inc.—2325
Web Controls Corp.—1729
Welding Design & Fabrication—1111

Flat bed body which generally transports solid cargo is quickly converted to a liquid carrier . . . with a SEALDTANK*

ENJAY BUTYL

Converts trucks to liquid carriers in minutes!

Enjay Butyl is used by the United States Rubber Company for "Sealdtanks" carrying up to 4,200 gallons. Sealdtanks are tube-like containers that can be rolled into compact units and stored on the truck when it returns with dry cargo. Note rolled Sealdtank at rear. Why was Enjay Butyl chosen for Sealdtanks? Because its excellent resistance to many chemicals, its remarkable toughness as well as all-weather resistance make it a most practical container for transporting various liquids.

*Trademark, U.S. Rubber Co.

Versatile Butyl may well help improve the performance of your own products. Complete information and expert technical advice is available to you from Enjay.

ENJAY® BUTYL

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ENJAY COMPANY, INC.

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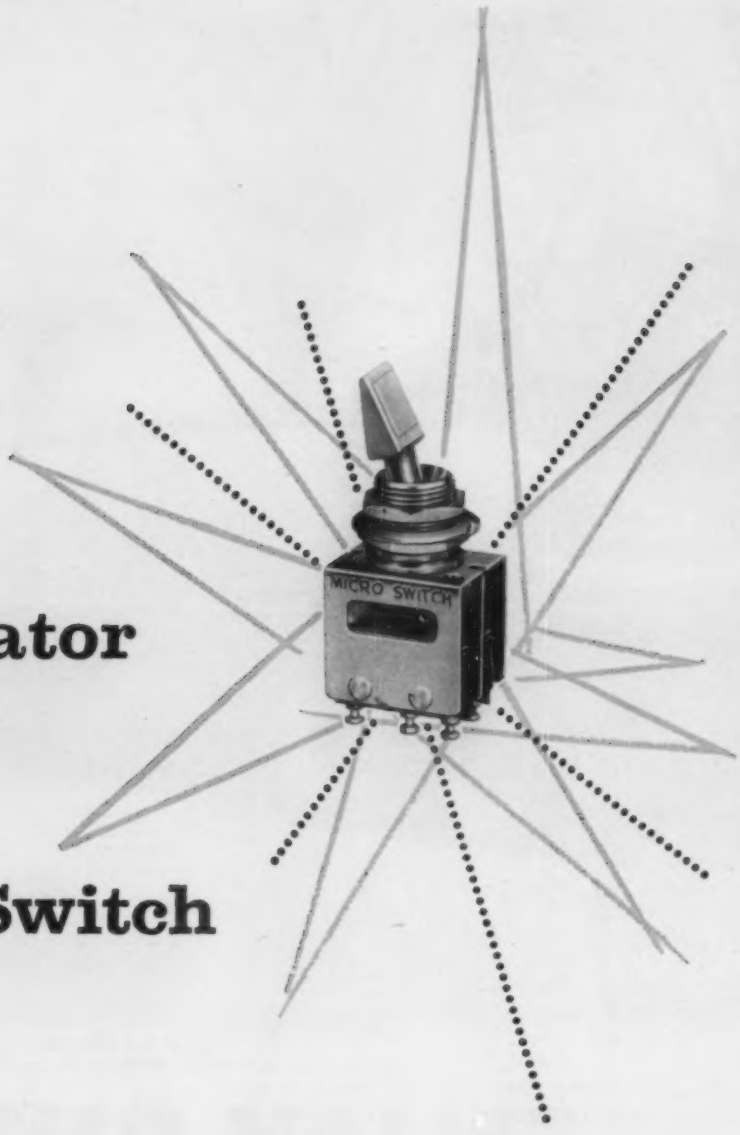
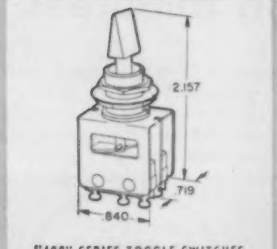
New Tab-Indicator Toggle Switch





"400" SERIES TOGGLE SWITCHES
Five models available, including 2-position and 3-position types. All are rated at 5 amperes, 250 vac.

The new "400" Series Toggle Switch from MICRO SWITCH has a paddle-shaped tab which can be numbered or color-coded as an indicator. The standard model has a natural metallic finish which will maintain a fresh appearance through long and constant use. The anodized aluminum tab is also available in black or in colors.

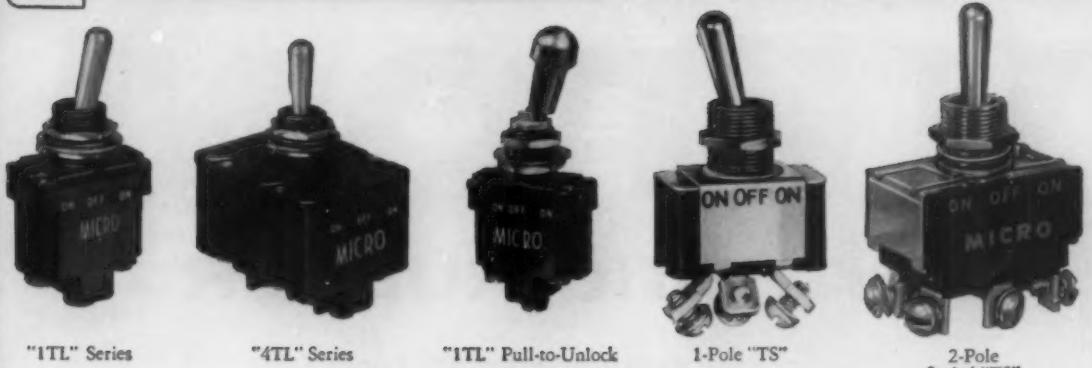
The basic switches used are precision snap-action, long-life units, requiring a minimum of space. They conform to specifications for MIL-S-6743, with two isolated single-pole double-throw circuits. Turret terminals make wiring easy, and contact enclosures are dust-tight.

Five models are presently available in the "400" Series, including both momentary and maintained contact types. Write for Data Sheet No. 174 describing these new tab-indicator toggle switches.

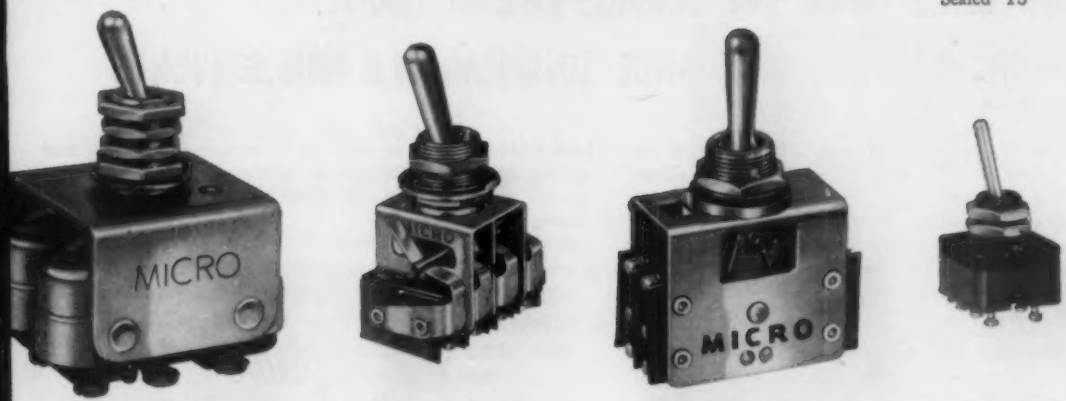
HONEYWELL
ENGINEERING THE FUTURE

H HONEYWELL

MICRO SWITCH Precision Switches



"1TL" Series | "4TL" Series | "1TL" Pull-to-Unlock | 1-Pole "TS" | 2-Pole Sealed "TS"



Hermetically Sealed Assembly | 4-Switch Assembly | "Electrical Memory" Assembly | Subminiature "TM"

Precision Toggle Control Can Be Customized

MICRO SWITCH manufactures hundreds of different toggle switches and toggle switch assemblies. In this complete line you can find the exact characteristics and contact arrangements you need.

"TL" Series Silicone sealer between cover and case seals against dust or moisture. These switches are approved under MIL-S-3950A, operate in a temperature range of —85°F to +250°F. Available in 1, 2 and 4-pole models with integral terminals.

"TS" Series The toggle lever is sealed against dust and moisture. "TS" toggles meet specifications for MIL-S-3950A. Special plastic barrier plus extra distance between terminals. A keyed bushing prevents rotation. Wide choice of contact arrangements includes 1, 2, 3 and 4-pole types.

Subminiature "TM" Weighs only 4½ grams, measures only ½" x ½" at the base. Double-pole double-throw with wide temperature range and low circuit resistance.

"AT" Series Toggle Assemblies MICRO SWITCH offers toggle switch assemblies of up to 16 basic switches. Hermetically sealed types are also available.

There is a MICRO SWITCH branch office near you and prompt engineering help on the selection of toggle switches is available by simply checking the Yellow Pages. Be sure you get MICRO SWITCH precision and reliability.

WRITE FOR NEWLY REVISED CATALOG 73 ON TOGGLE SWITCHES

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

H HONEYWELL **Honeywell**
MICRO SWITCH Precision Switches

CIRCLE 165 ON READER SERVICE CARD

DU PONT IMPROVES

VITON®

SYNTHETIC RUBBER

- NOW GIVES TWICE THE SERVICE LIFE AT 600°F.
- OFFERS GREATER RESISTANCE TO CHEMICALS AND SOLVENTS

VITON's remarkable resistance to heat and fluids has already improved performance of components for appliances, autos, aircraft and many types of industrial equipment. Now the ability of this new synthetic rubber to withstand heat and chemical exposure has been extended to even greater limits. Here are some of the properties of the new high-performance grade, now commercially available in a wide range of products.

Improved resistance to heat aging—When oven-aged in air at 400° F. or less, VITON vulcanizates now remain usefully elastic for *indefinite periods*. At higher temperatures, they can be expected to remain usefully elastic for more than:

3000 HOURS @ 450° F.
1000 HOURS @ 500° F.
240 HOURS @ 550° F.
48 HOURS @ 600° F.

Improved resistance to fluid exposure—VITON now has better resistance to nitric acid, glacial acetic acid and hydrochloric acid, as well as to certain aromatics and diester lubricants. Its proven resistance to a wide variety of oils, solvents, fuels and chemicals remains unequalled among synthetic rubbers.

Complete information—Learn more about VITON, and how it can improve the products you make and use. Technical literature just published will give you all the facts. Write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. PE-5, Wilmington 98, Del.

DU PONT
REG. U. S. PAT. OFF.

SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

OTHER IMPORTANT PROPERTIES OF VITON

Hardness: 60 to 95 durometer on the Shore A scale.

Tensile strength: 2000 to 3000 psi. at room temperature, with elongation from 100% to 400%, depending on hardness; at 300° F., tensiles of 300 to 1000 psi., with elongation from 80% to 200%.

Compression set: VITON vulcanizates recover to within 90% to 97% of original dimensions when compressed 25% and held at 250° F. for 70 hours.

Low temperatures: Specimens 0.075 in. thick have a Young's modulus of 10,000 psi. at −20° F. and a brittle point of −47° F. A 0.010 in. thick coating of VITON on wire did not crack at −90° F., when bent around a mandrel 10 times the diameter of the wire.

Ozone and weather: VITON has withstood 28 days in 100 ppm of ozone, without a crack! After twelve months' exposure to direct Florida sunlight, it still remained in perfect condition.

Electrical: Typical values—DC resistivity of 1.4×10^{14} ohm-cm; specific inductive capacity of 8.53; power factor of 2.5%; dielectric strength of 412 volts/mil.

CIRCLE 3 FOR HANNIFIN→
CIRCLE 167 FOR FITTINGS & HOSE→

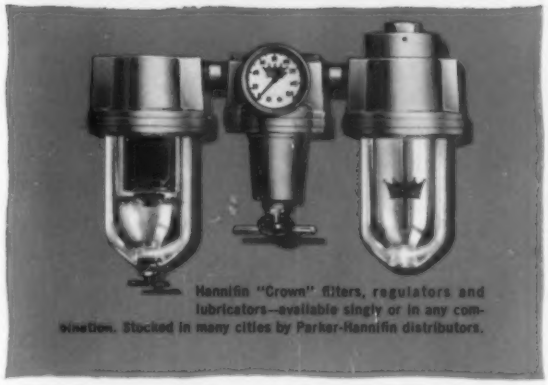
Hannifin air power cylinders, available in a full range of mounting styles, bore sizes from 1½" through 14", strokes to 20 feet. Cylinder bodies bored, then honed satin-smooth . . . for low friction, long packing life.

Hannifin's complete line of air control valves includes electric solenoid-, pressure-, cam-, hand-, and foot-actuated valves. Write for our compact new "Valve Finder."

PARKER-HANNIFIN puts air to work without costly leaks

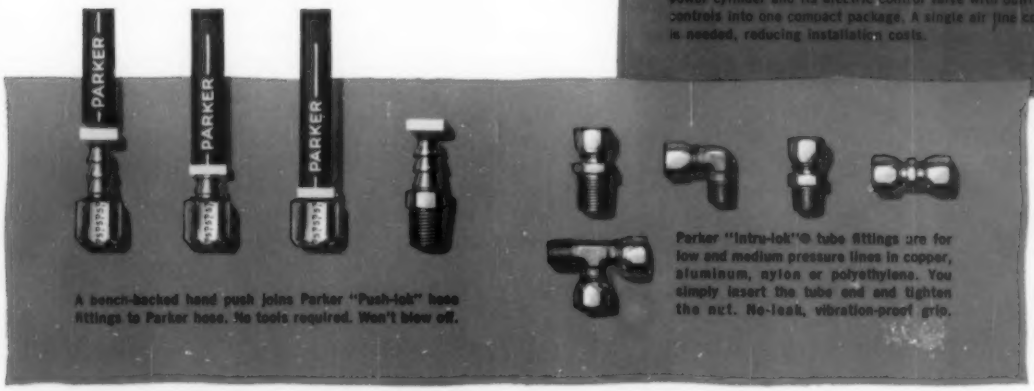
Now... complete pneumatic power systems, engineered for long leak-proof life, are available from your Parker-Hannifin man. Hannifin "Crown" units supply filtered, lubricated air at optimum pressure. Hannifin air valves shift quickly and seal bubble-tight. Hannifin air cylinders and air motors are low-friction, leak-proof. Parker "Push-lok" hose fittings and "Intru-lok" tube fittings provide quick, easy, leak-proof connections. The over-all result is more work from less air!

Our field engineering service helps you design your circuits and select the components. Many items are available locally, from Parker-Hannifin distributor stocks.



Hannifin "Crown" filters, regulators and lubricators—available singly or in any combination. Stocked in many cities by Parker-Hannifin distributors.

The Hannifin air motor combines a high-efficiency, leak-proof power cylinder and its electric control valve with built-in speed controls into one compact package. A single air line connection is needed, reducing installation costs.

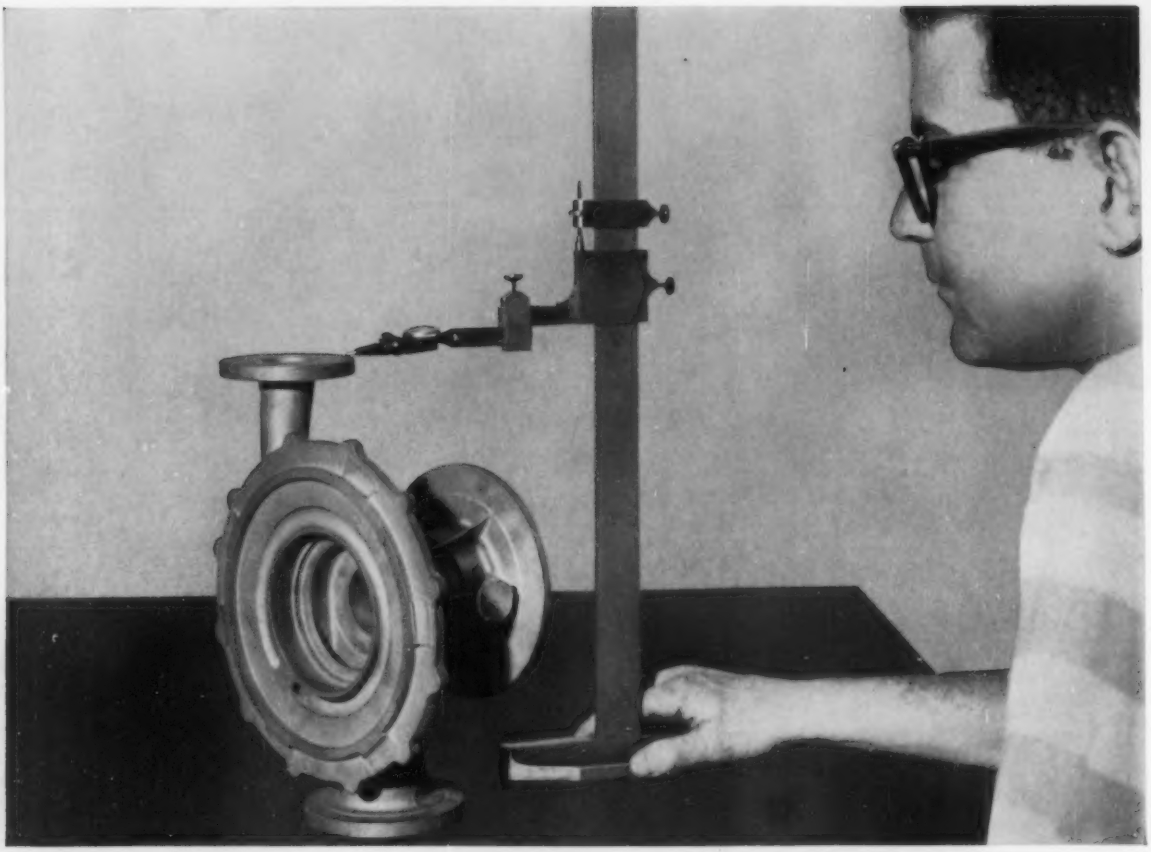


A bench-backed hand push joins Parker "Push-lok" hose fittings to Parker hose. No tools required. Won't blow off.

Parker "Intru-lok"© tube fittings are for low and medium pressure lines in copper, aluminum, nylon or polyethylene. You simply insert the tube end and tighten the nut. No-leak, vibration-proof grip.

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

HANNIFIN COMPANY
555 S. Wolf Road, Des Plaines, Illinois



Arwood adds a new dimension to investment casting—

SIZE

Until now, an investment casting has been something you could hold easily in one hand. Today, thanks to a series of technological breakthroughs, Arwood can offer you investment castings so large and heavy that you need two hands even to budge them from the floor!

The new weight limit approaches 100 pounds.

What does this mean to you? It opens a whole new realm of possibilities in the design of component parts. For the first time, a designer can avail himself of investment casting's special advantages over a complete size range that runs from a fraction of an ounce up to weights heretofore available only in sand castings. Advantages like investment casting's ability to reproduce complex, hard-to-machine shapes in any castable metal or alloy . . . its low initial tooling expense . . . the dimensional accuracy and smooth surface finish characteristic of investment cast parts.

So . . . for quality investment castings in any ferrous or non-ferrous alloy . . . and in any size and weight . . . check with Arwood. We can free your hands to design for function and end use, because we can give you the *shape* you need in the *metal* you need in the quantity you need, no matter how *large* the part on your board. All five Arwood plants stand ready to serve you.

Write for your free copy of our 44-page "Practical Guide to Investment Casting."

Visit us in Booths 117 and 119 at the Design Show

Machine the simple . . . cast the complex

A complete service from design through tooling, production and finish machining. Seventy-one engineering representatives from coast to coast.

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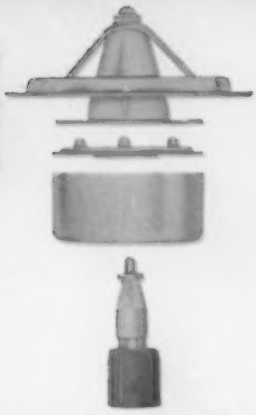
AGAIN-



EXPLODED VIEW OF AUTOSTAT® made by FULTON SYLPHON DIV., Robertshaw-Fulton Controls Co., shows impact extruded cup made from Revere Copper Rod. Other parts of this superior thermostat used in pressurized cooling systems in automobiles and other automotive equipment, are made of 70/30 Revere Brass Strip.

Revere helps "fit the metal to the job"

AND A LEADING MANUFACTURER OF AUTOMOTIVE THERMOSTATS IS ABLE TO PRODUCE A SUPERIOR PRODUCT FOR LESS MONEY

That little unimportant-looking copper cup shown above originally posed a king-sized production problem. It is a critical part of a newly designed automotive thermostat made by the Fulton Sylphon Division of the Robertshaw-Fulton Controls Co., Knoxville, Tenn.

In the early stages this copper cup was machined from free cutting copper rod, but this proved costly due to the high rate of scrap from the machining operation and the relatively high cost of turning out the machined part. At this point Revere Technical Advisors got together with Fulton Sylphon Engineers and the possibility of an impact extrusion was discussed. Revere T.A.'s in turn contacted suppliers who might furnish these extrusions in copper, to see whether or not they could be produced economically and to the demanding specifications required.

After exhaustive tests it was found that the cup could be impact extruded to meet the exacting hardness specifications of Fulton Sylphon. During its development, many problems involving temper, grain size and control of the chemical composition of the copper rod had to be solved.

In addition to the Copper Cup, Revere also supplies 70/30 Brass Strip from which other parts of the AUTOSTAT® are fabricated.

Said a Fulton Sylphon purchasing agent, "When you ask Revere for help you really get results."

This is still another case of how Revere, a supplier, working with still another supplier, was able to help its customer produce a superior product for less money. Why don't you take advantage of this service?

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue

New York 17, N. Y.

Mills: Rome, N. Y.; Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calhoun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

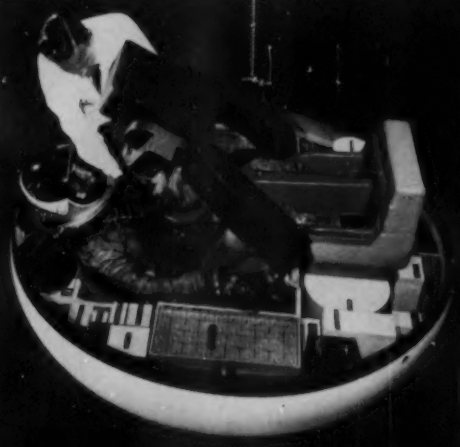
CIRCLE 169 ON READER SERVICE CARD

CIRCLE 170 ON READER SERVICE CARD→

Applications

URETHANE FOAMS

Available in flexible, semi-rigid or rigid form, these lightweight, tough and durable materials are adaptable to almost any type of fabricating technique: sliced, stitched, stapled, contour cut or molded in place. *Function:* Cushioning, shock padding, void filling, acoustical and thermal insulation, packaging, molded forms, structural panels, air and fluid filters, fabric lining.



Astronaut Space Couch produced for Astro Systems Research Laboratories, Norair, Division of Northrop Corp., by American Latex Products Corp.

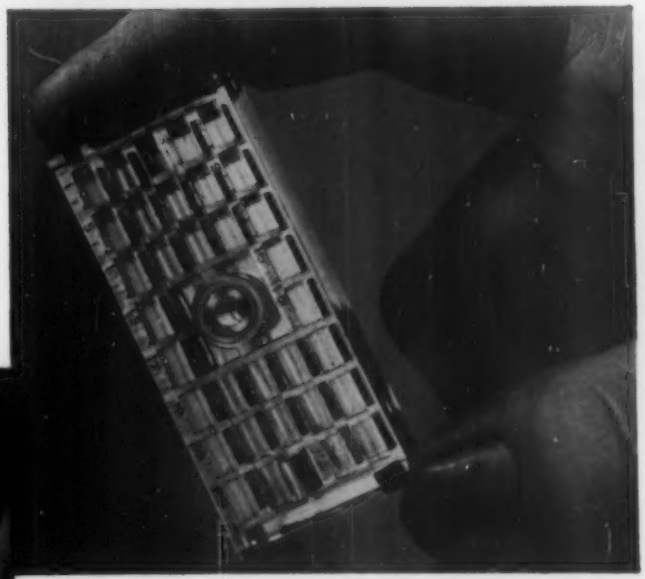
URETHANE COATINGS

A chemically-engineered protective coating that builds a glossy protective armor through chemical cross-linking of its molecular structure. Highly resistant to impact, abrasion, corrosion, chemical attack with a light reflectance rating 15 points higher than clear plate glass! *Function:* Solderable wire coatings, marine finishes, storage tank lining; flexible coatings for rubber, leather, paper, textiles, conveyor belts; hard coatings for ceramics, hardboard, swimming pools, structural uses.

ISOCYANATES developed and manufactured by Mobay are the "building block" chemicals used to create the urethane materials shown. Isocyanates are efficient modifiers of many common compounds, fluids and fibers which, in turn, affect the design potential for standard functional units. *Examples:* May be used to modify self-adhering characteristics of compounds, control solubility or viscosity of fluids and greases, reduce shrinkage of fibers, improve mechanical strength of certain solid polymers, increase wear properties of leather and wet strength of paper. Ad infinitum.

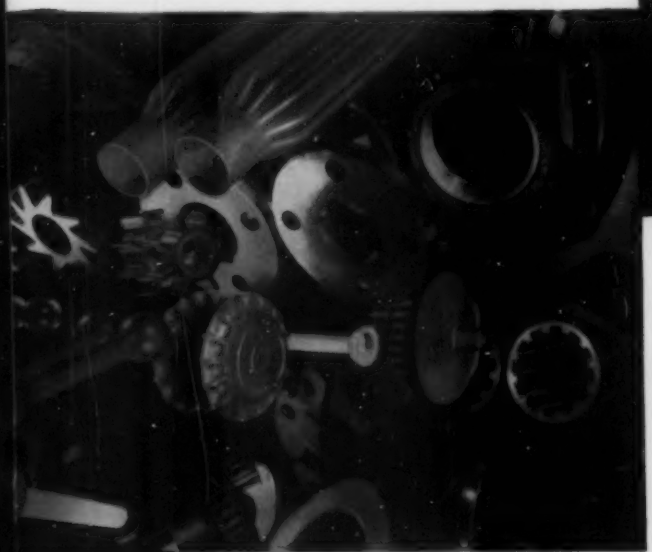
Unlimited...

with materials designed to whet your creative engineering talents



URETHANE ELASTOMERS

One of the very few elastomeric compounds which combines high hardness and density with resilience and elasticity. Exceptional impact strength and resistance to wear and aging, abrasive slurries, solvents, greases and oils. Cast from liquid Multrathane® chemicals in simple molds. *Function:* Long-wearing, silent gears, pump parts, power belts, couplings, shock mounts, solid tires, pullies, diaphragms, sheave lining, encapsulations.



MERLON® POLYCARBONATES

The newest and most versatile of the industrial thermoplastics, Merlon combines excellent dimensional stability, exceptional mechanical strength and good electrical properties over a wide temperature range. May be injection molded, extruded or vacuum formed, or machined from tube or bar stock. Self-extinguishing. *Function:* Computer parts, electrical components, meter cases, housings, grilles, pump impeller parts, bushings, tubing, lenses.

If your field of interest lies in any category of product engineering which requires materials with unusual combinations of unconventional properties, you will find these urethane and polycarbonate materials an interesting and fertile field for exploration. Write Mobay Chemical Company for technical literature, properties and application data based on design and engineering case histories. For prompt assistance, please enclose specifications and use requirements if available.

DESIGN ENGINEERING SHOW
May 23-26

Space 1135
New York Coliseum

p-1

MOBAY
First in Urethane Chemistry

MOBAY CHEMICAL COMPANY
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Mobay manufactures isocyanates, polycarbonates, and urethane chemicals for foams, elastomers and coatings.

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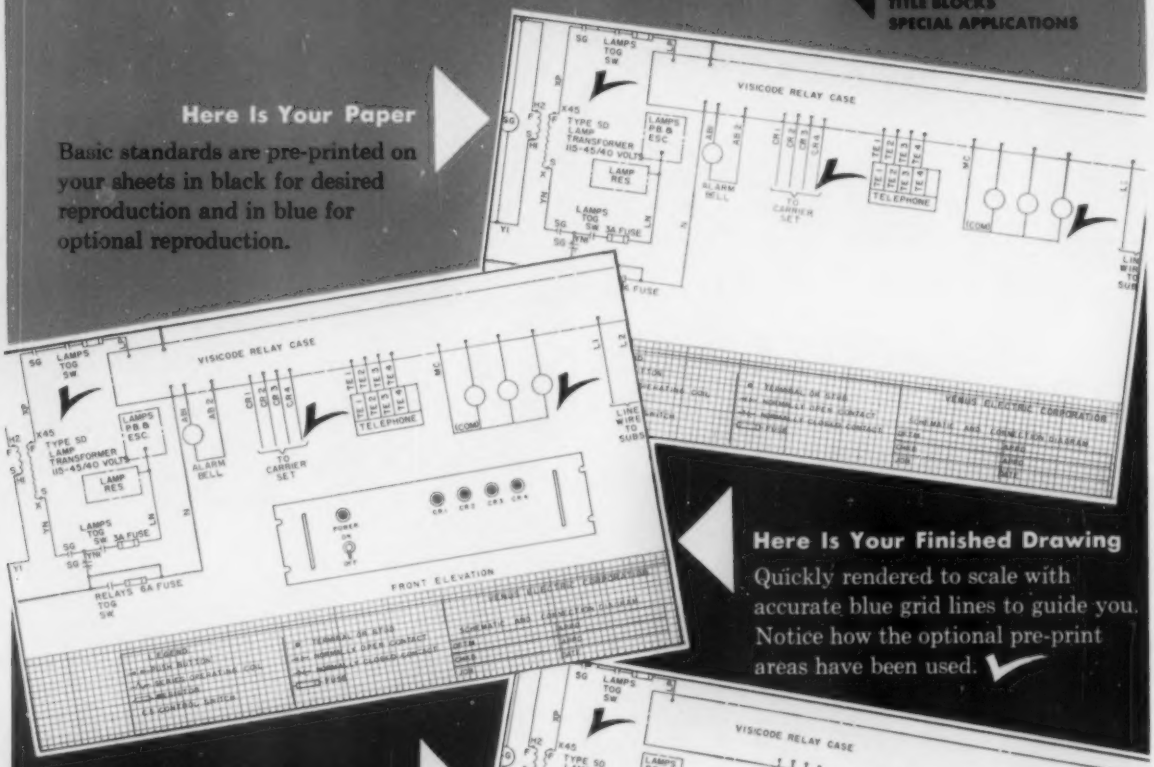
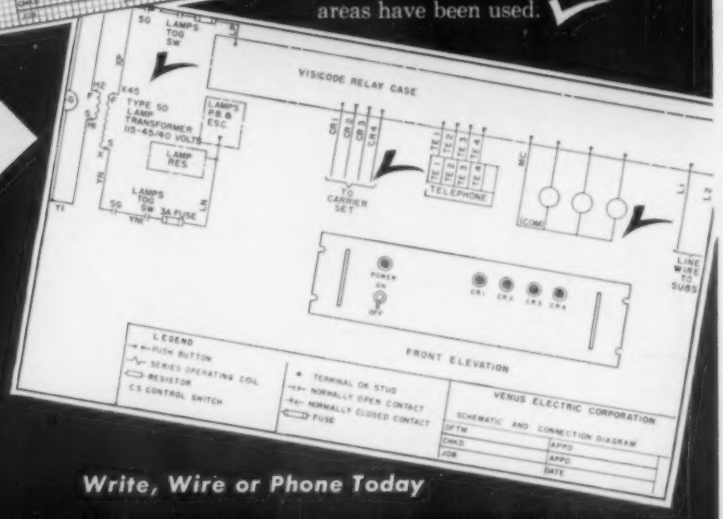


Here Is Your Finished Drawing

Quickly rendered to scale with accurate blue grid lines to guide you. Notice how the optional pre-print areas have been used.

Here Is Your Finished Print



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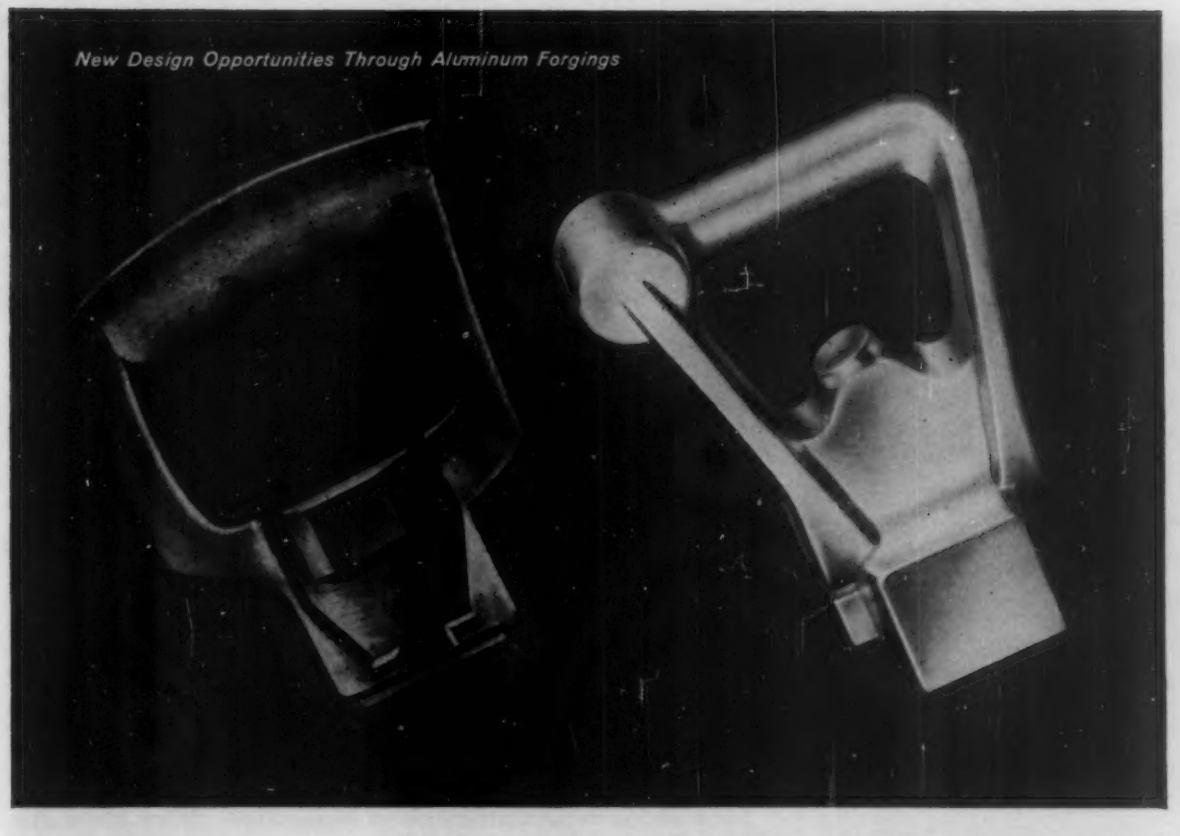

WHICH DRILL HANDLE HAS THE WEIGHT ADVANTAGE?

The handle on the right . . . because it's aluminum! This forged aluminum drill handle is a good example of how aluminum forgings are solving difficult design problems involving light, strong tool parts.

Previously, the handle was fabricated as an iron casting . . . and iron castings are *heavy*, as workmen using the drill soon found out. To lighten the worker's load, a search began for a new design that would reduce the weight of the handle, yet retain its strength.

Solution: the aluminum forging shown in the picture. It weighs only one-third as much as the old cast iron handle. Yet, due to the forging process, its strength is even greater. Grain flow lines of the metal follow the contour of the part, concentrate at points of greatest stress and shock to give the handle amazing strength.

This highly favorable strength-to-weight ratio is one reason why so many designers are turning to aluminum forgings for more and more commercial applications. Find out how aluminum forgings can best serve your requirements. We'll be glad to send you full details on aluminum forging availabilities, tolerances and hand forging designs—just mail the coupon!

KAISER ALUMINUM*

THE BRIGHT STAR OF METALS

*TRADEMARK KAISER ALUMINUM & CHEMICAL CORP.

Kaiser Aluminum & Chemical Sales, Inc.
Dept. FO-1089, Kaiser Center
300 Lakeside Drive, Oakland 12, Calif.

Please send me the latest information on commercial aluminum forging availabilities, tolerances and hand forging designs.

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COMPANY _____

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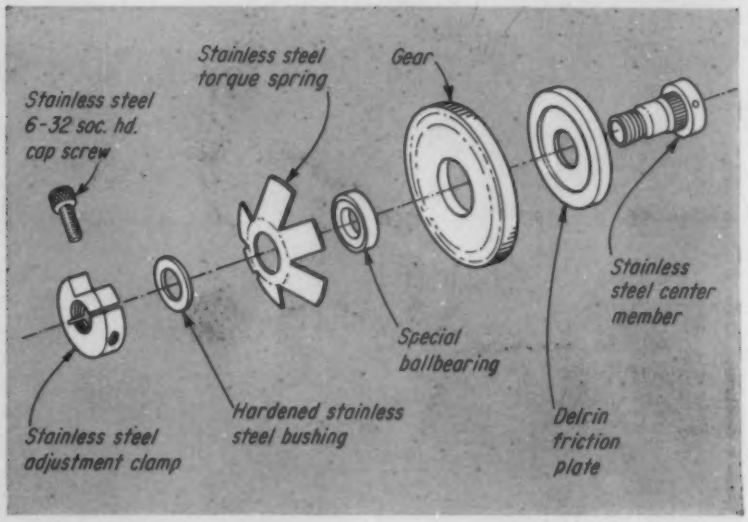
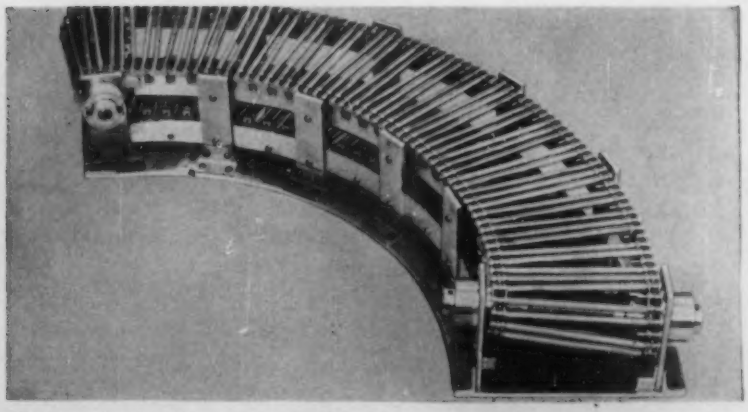
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES

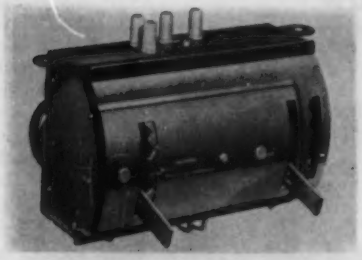
These mechanical components, electrical devices, fluid power and control systems, materials of construction, and engineering department equipment are being introduced at the 1960 Design Engineering Show, The Coliseum, New York City, May 23 to 28, and have not been previously described in PRODUCT ENGINEERING.

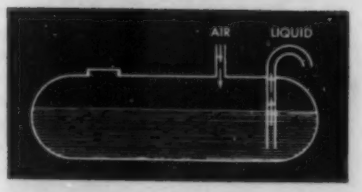


Slip clutch eliminates galling . . .
and is also said to maintain more uniform slipping torque. Where friction plate, gear and clamp spring in conventional clutches of this type tend to gall after prolonged slipping, this device mounts the gear on a ballbearing and uses a stainless bushing under spring. Adjustable to predetermined torque value, new clutch is intended for use in gear trains as tensioning and protective device. Available with diametrical pitch of 48, 64, 72, 80, 96, 120. Pitch dia from 0.750 to 2 in., with pressure angle for 14½ or 20°. **Dynamic Gear Co Inc, Dixon Ave, Amityville, NY.** See Booth 1104 or
Circle 300 on Reader Service Card



Chain of tubular cross-members . . .
for power transmission or materials-handling applications can be designed to operate around corners. All wearing surfaces are hardened. Made in ½-in. pitch, No. 40; and ⅜-in. pitch, No. 50 sizes. Available for three different radii: 15, 20 or 30 in. Offered in either steel, with galvanized zinc finish, or stainless. **Acme Chain Corp, Holyoke, Mass.** See Booth 413 or
Circle 301 on Reader Service Card





Multiple-liquid dispenser . . .

system utilizes air rather than a pump to dispense two or more liquids separately and in specified phases of a cycle. Automatic control (see top photo), coupled with pump, controls metering specific amounts of liquid. Air-expansion system, housed in chamber apart from reservoirs, takes place of conventional pump immersed in liquid that may cause oxidation, corrosion or gumming of mechanism. Said to be the first dispenser system that can operate more than a single liquid reservoir. Permits flexibility of reservoir capacity. **Detroit Control Div, American-Standard, 5900 Trumbull Ave, Detroit 8.**

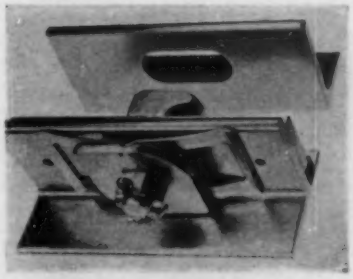
See Booth 1230 or
Circle 302 on Reader Service Card

One-direction rotary switch . . .

available with 20 and 35° overtravel, is for use where sensitive, snap-action rotary operation is required. Mounts on clean, smooth surface with lockwashers under mounting-screw heads. Operating torque is rated at 4 in.-gm max; release torque at 0.5 in.-gm min. Contact separation is 0.008 in. min. UL listing for switch is 5 amp, 120/240 v ac. Actuator levers of customer-design may be used with switch because brass actuating shaft is drilled and slotted to accept actuator wire. Torque produced by weight of actuating lever should not exceed min specified release torque. Reported to withstand electrical life of 100,000 actuations; mechanical life of 5 million actuations min. **Acro Div, Robertshaw-Fulton Controls Co, Columbus 16, Ohio.** **See Booth 427 or**
Circle 303 on Reader Service Card

Double-capacity web control . . .

is offered in nine sizes. Redesign of existing units resulted in doubling capacity. Cost, however, is only 50% higher than single-capacity units. Clutch and brake units lend themselves to tapered tension winding without resorting to cam or program modulation of flux in many winding jobs. Also suitable for programed torque control. Tensions of unwind or rewind are programed from movement of follower-arm sensing roll build-up, translated into movement of brush arm of autotransformer that produces, at will, an exponential straight line or any modulated curve. Units are used for controlled inertia of moving or rotating bodies such as indexing of tables in automatic machinery, controlled deceleration and stopping of conveyor-type operation, and frequent damping of heavy rotating bodies. **Web Controls Corp, 318 Briarcliffe Rd, W Englewood, NJ.** **See Booth 1729 or**
Circle 304 on Reader Service Card



Quarter-turn locks bolt fastener . . .

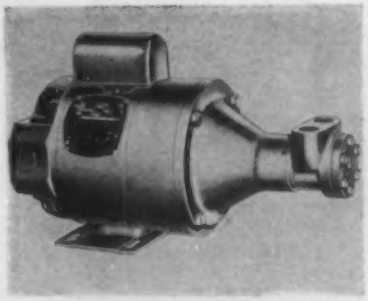
and attains proper sealing pressure without use of torque wrench or other adjustments. Spring does not carry load, but holds stud in position during locking and unlocking. Infinitely adjustable to any predetermined torque. Shear and tensile load ratings are equal to standard bolt. Now available in ¼- and ⅜-in. dia sizes. **Simmons Fastener Corp, N Broadway, Albany NY.**

See Booth 2434 or
Circle 305 on Reader Service Card

High-strength film adhesives

are thermosetting. Applicable to structural bonding and honeycomb sandwich construction. Said to provide uniform adhesive thickness throughout joint, controlled confinement of adhesive to immediate bonding area and clean bonding operations. Because film adhesives do not contain solvents, waste and shrinkage are avoided. Available in varying widths and thicknesses and can be die-cut into complicated shapes. Shear strengths range from 3040 to 4180 psi with peel strengths ranging from 55 to 110 lb per in. width at 75 F service. Said to have excellent resistance to water, 20% salt spray, hydraulic oil and aromatic fuels. High bond strength in excess of 2500 psi tensile shear strength is reported to be obtainable with cure time as low as 2 to 3 min. at temperatures in 400 to 450 F range. **Adhesives, Coatings and Sealers Div, Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul.**

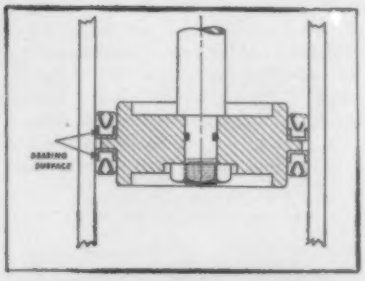
See Booths 1718 and 1720 or
Circle 306 on Reader Service Card

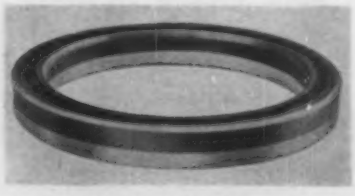


Small, motor-mounted pump . . .

is available in ½, 1½ and 3-gpm sizes integrally mounted with 1750-rpm motors. Pumps handle liquids up to 7500 SSU and up to 500 psi, including lubrication oils and fuel oils above 100 SSU. **Viking Pump Co, Cedar Falls, Iowa.**

See Booth 824 or
Circle 307 on Reader Service Card

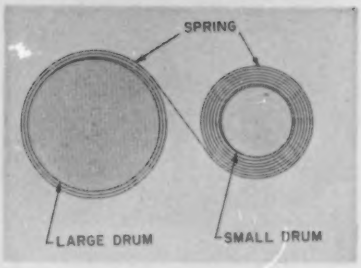




Bonded-case U-packing . . .

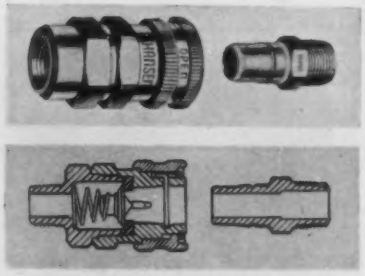
for hydraulic systems sealing has built-in bearing, which rides on close-tolerance case. Case can be brass or variety of other materials. Packing is press-fitted on piston. Eliminates follower or backup plates. **International Packings Corp, Bristol, NH.** **See Booth 1309 or**
Circle 308 on Reader Service Card

continued on page 176



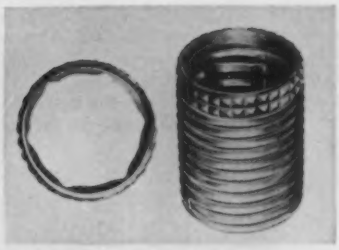
Tubular-shape spring motor . . . uses flat strip of stainless steel, 0.0033 in. thick and 7⅞ in. wide, as spring material. Curvature has been obtained by continuous heavy forming so that in relaxed condition it is tightly wound roll of flat material. Cross-curving effects have been eliminated by mounting spring material on two steel drums (see end-view sketch). Drums of illustrated unit are bearing-mounted in frame for low friction so that constant force is exerted as extension of output cable winds unit from relaxed condition on ½-in.-dia drum onto larger ¾-in.-dia output drum. Constant torque of 6 in.-lb is developed through 50 revolutions of output pulley at all positions of cable extensions. Motors are custom-engineered for individual applications with shapes to adapt to flat or tubular spaces. **Hunter Spring Co, 1 Spring Ave, Lansdale, Penna.**

See Booth 1512 or
Circle 309 on Reader Service Card



Locking-ring couplings . . . are said to provide quick connection and disconnection of air-line circuits with automatic flow or shutoff, and will handle more volume than other couplings of equal dimensions. Couplings will handle any connections from ⅛ to 1 in. Sockets and plugs in series are interchangeable, eliminating need for various-size couplings in air-line circuit. Compact construction makes couplings applicable where space limitation would prohibit use of larger physical dimensions. **Hansen Mfg Co, 4031 W 150th St, Cleveland 35.**

See Booth 628 or
Circle 310 on Reader Service Card

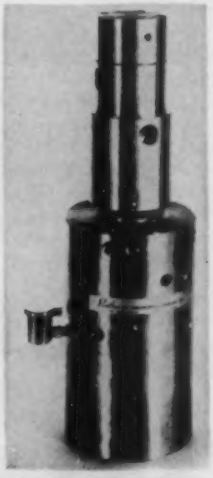


Thin-wall locking insert . . . is made of high-strength material with internal thread lock that exceeds MIL-N-25027. Lock design is flexible and said not to damage bolt or insert in performance. Reported to offer use in wide temperature range, light weight, easy direct replacement of wire-type inserts, positive external lock, min edge distance and corrosion resistance. Available in aircraft and commercial qualities in sizes No. 10 through ½ in. Internal thread lock is standard only in aircraft series. **Rosan Inc, 2901 West Coast Highway, Newport Beach, Calif.**

See Booth 1215 or
Circle 311 on Reader Service Card

Air filter . . . for use with most air-handling equipment, such as engines, compressors and pressure blowers, consists of cylinder made up of layers of highly inert, bonded fiber sandwiched between two layers of aluminum screen cloth. Ends of the cylinder are embedded in plastic material that forms gasket between element and retaining hardware. Air filtering efficiency is said to be better than 98% with particles of 5-micron mean dia or greater and almost 100% efficient with particles of 20 microns or larger. Pressure loss is 0.3 to 0.4 in. water. Suitable for operation up to 250 F; or to 300 F for intermittent operation. Available in variety of sizes and shapes. **Air-Maze Corp, 25000 Miles Rd, Cleveland 28.**

See Booth 1134 or
Circle 312 on Reader Service Card



3-passage rotating joint . . . has two hydraulic passages and one air passage for use on water-cooled air clutches. Operates at speeds to 900 rpm. Seals against 100-psi differential between air and hydraulic pressure. Internal construction of unit is bronze and stainless steel; casing is aluminum. Carbon seals are used exclusively and are reported to provide max sealing with min torque and wear. **Rotherm Engineering Co, 7280 W Devon Ave, Chicago 31.**

See Booth 2419 or
Circle 313 on Reader Service Card

Hydraulic packing material . . . is synthetic compound that includes a plastic and an elastomer. Reported to be highly resistant to abrasion, and usable in both acid and alkaline applications. Laboratory evaluations are said to have set tensile strength of new compound at over 3000 psi. Elastic limit is almost 300%. Material seals effectively in air, oil, water

continued on page 178

Whatever your design problem there is a

Faultless Caster

to solve it!

Design Problem:
Shimmyless, Quiet-running Caster for Hospital Carts and Stretchers

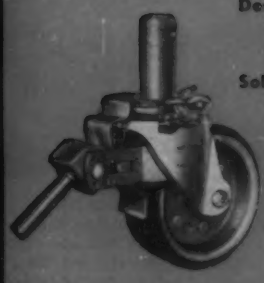
Solution:
Series 2400 Medium Duty Swivel Stem Truck Caster. Hardened ball bearings running in 2 raceways machined to closely held tolerances. Precision adjustment of swivel assembly elimates troublesome wobbling of ordinary kind. 5", 8" or 10" dia. wheels for smooth, noiseless rolling

Design Problem:
V-Grooved Wheel to Follow Angle Iron Tracks

Solution:
Light, medium and heavy duty casters are available with 4" to 10" V-Grooved Wheels to carry loads from 325 lbs. to 15,000 lbs. along unobstructed tracks. Save floor surfaces, eliminate noise and vibration. V-Grooved Wheels have flat outer treads for use on floors.

Design Problem:
Cushion Action Caster for Level Ride over Irregular Floors

Solution:
Series SH300 Spring Action Swivel Plate Truck Caster eliminates bounce. Caster maintains continual floor contact. Durable, long-lasting spring and draw bars, on center line of wheel, absorb shock and lengthen life of ball bearings, raceways and wheels.



Design Problem:
Scaffold and Platform Caster that Double Locks against Movement

Solution:
Series C900 Scaffold Caster has Brake that simultaneously locks both swivel and wheel. Scaffold will not creep. Foot or hand operated brake lever locks in up position . . . releases in down position. Large diameter wheel for smooth rolling over ordinary obstacles.

Design Problem:
Sealed Caster Bearings for Use in Extreme Temperatures or Moisture-laden Air

Solution:
Series 900 GS Swivel Plate Truck Caster has built-in protective grease seals around main load, thrust and wheel bearings. Exclude water, chemicals, dirt. Prevent grease leaking to floor, assure easy maintenance, low upkeep.

Design Problem:
Exciting, All-New Caster Concept To Enhance Your New Furniture Line

Solution:
Royal-Roll, the "King of Casters" combines unique styling and time-tested furniture caster engineering. Double ball bearing swivel, non-marking wheel and hooded horn. Spherical black wheel with bright nickel or brass horn. Stems for wood, tubular metal and cast legs.

For FREE Condensed Catalog, or more information on specific Casters, fill out coupon today. Or contact your nearby Faultless Distributor who is listed in classified directory under Faultless heading.

Tell me more about:

- ☐ Series 2400
- ☐ V-Grooved Wheel
- ☐ Series SH300
- ☐ Series C900
- ☐ Series 900 GS
- ☐ Royal Roll

Faultless Caster Corporation
Evansville 7, Indiana

Name_____

Title_____

Company_____

City_____ State_____

FROM ¼ HORSEPOWER —

ACTUAL SIZE NO. 25, ¼" PITCH

Average Tensile Strength of 825 lbs.

TO

1000 HORSEPOWER

Average Tensile Strength 95,000 lbs.

ACTUAL SIZE NO. 200
2½" PITCH

ACME Roller Chain applications range from fractional horsepower drives to those in excess of a thousand horsepower.

The ACME ¼" pitch roller chain, weighing less than two ounces per foot, is used on such intricate machines as microfilm projectors, electronic controls and many other similar applications.

ACME large pitch chains of multiple strands, weighing 40 to 50 pounds per foot, are available for heavy duty service on heavy machinery.

Use ACME Roller Chain Drives and be assured of these inherent characteristics:

1 High efficiency throughout the life of drive.
2 Constant speed ratio between the driving and driven shaft.
3 Minimum loads on shaft bearings.
4 Sufficient elasticity to absorb shock loads.
5 Maximum life expectancy.
6 Large speed ratios — up to, and including 6 to 1.

Your local Distributor can supply you promptly with ACME Roller Chains in 12 standard sizes, from ¼" pitch, ⅛" width to 2½" pitch, 1½" width.

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Write Dept. I-N for new 100-page illustrated technical catalog including new engineering section showing 36 methods of chain adjustments.

Acme Chain Corporation
HOLYOKE MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

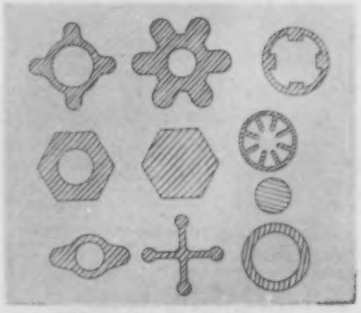
and water-based fire-resistant hydraulic media. Cup packing molded of the synthetic material is said to exhibit frictional potential as low as the best low-friction packings now available. For operating temperatures of 0 to 212 F. **E F Houghton & Co, 303 W Leigh Ave, Philadelphia.**

See Booth 1207 or
Circle 314 on Reader Service Card

One-shot switch-circuit devices

generate single, square-wave pulse in synchronism with clock pulse at each operation of pushbutton. For use in pulse and digital systems, assemblies can be used with clock pulse frequencies from 4 to 500 kc. Three different assemblies in series are each patterned to fit wide variety of clock pulse rise times, voltages and frequencies, and dc supply voltages. All circuit components are sealed in resilient potting material. **Micro Switch, Freeport, Ill.**

See Booth 1202 or
Circle 315 on Reader Service Card



Extruded metal shapes . . .

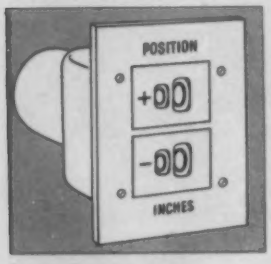
are now available in copper-base alloys in sizes from 1 to 8 in. dia, in 10-ft lengths. Production facilities are also said to permit secondary and hot- and cold-forming

continued on page 182

Veeder-Root READOUT Bulletin

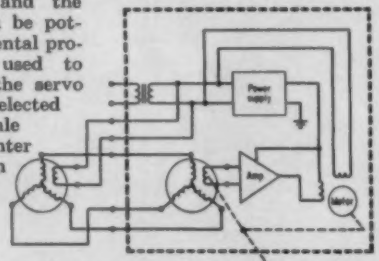
Readout Counter used in Tape Preparation for Machine Tool Control

A Veeder-Root Series 1538 Remote Data Readout Counter provides tape feed control for the motorized tape punching unit of the new Potter & Johnston Tape Control System. The tape punch is used to program machine functions on P & J Automatic Turret Lathes. The counter automatically controls the amount of tape feed required for each turret face involved, and stops the tape at preselected address points. When the correct address point is reached, a combination of holes representing the machine command is punched into the tape. Counter is automatically reset for each turret face.



Servo Repeaters Drive Counters to Indicate Lineal Motion*

One of the ways to take advantage of digital readout for indicating and recording information at remote points is through servo repeaters. Applications in aircraft, for altimeters, navigational displays and similar instrumentation, suggest many other opportunities to use counters for more positive indication and control. A typical "system" is shown here where a counter is used for indicating nuclear reactor rod position. The servo repeater and counter actually form one packaged unit, and the whole device can be potted for environmental protection. When used to drive counters, the servo gear ratio is best selected to provide full scale travel of the counter for one revolution of the control transformer shaft.



Typical servo repeater/counter device that converts synchro data to digital readout.

Output shaft to counter

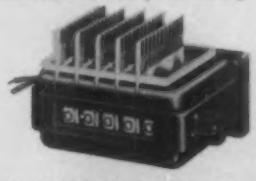
Let Veeder-Root help you make Counters do more! Extensive design experience and precision production techniques make it possible for Veeder-Root to help you solve a wide variety of digital, readout, control and recording problems with counters — from the simplest ratchet to advanced readout and navigational devices. Send for information on specific applications or contact your local Veeder-Root Counting Engineer.

*Reprinted from CONTROL ENGINEERING June 1959. Copyright© 1959 by McGraw-Hill Pub. Co., Inc. All rights reserved.

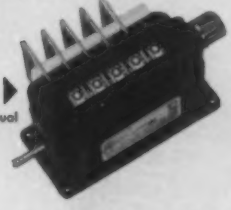
Veeder-Root Readout Device

This is the basic series of Remote Data Readout Counters. Some are available for standard applications, or design variations will be submitted based on requirements. They function basically as analog to digital converters.

Series 1538/electrical reset/ electrically actuated. Speed 1000 cpm, 3 or 5 figure



Series 1538/electrically actuated/ manual reset. Speed 1000 cpm, 3 or 5 figure



Series 1606/mechanically actuated manual reset standard; bi-directional (non-reset) available. Speed 5000 cpm, up to 5 figures

Veeder-Root

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CIRCLE 179 ON READER SERVICE CARD

CIRCLE 180 ON READER SERVICE CARD →

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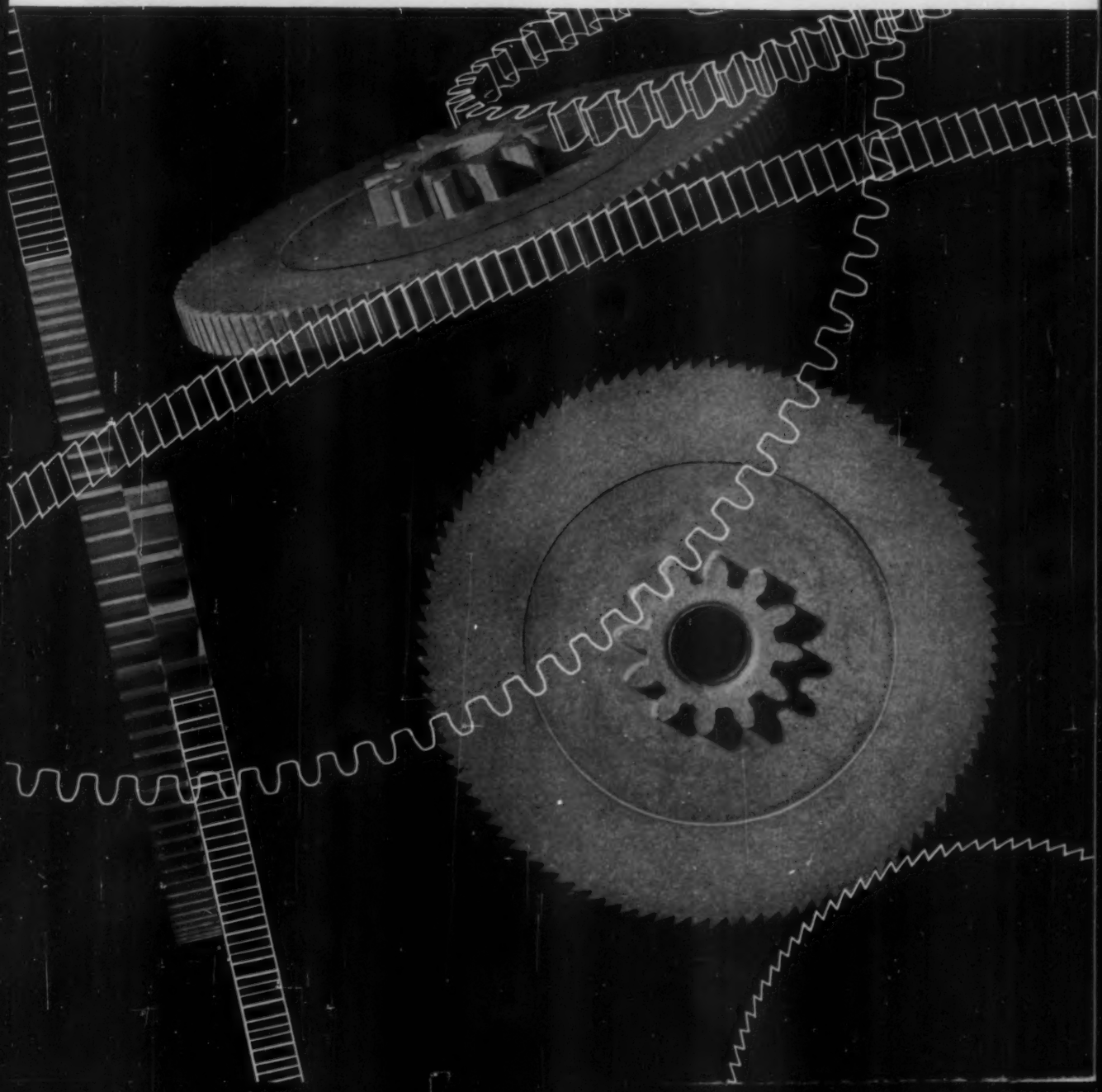
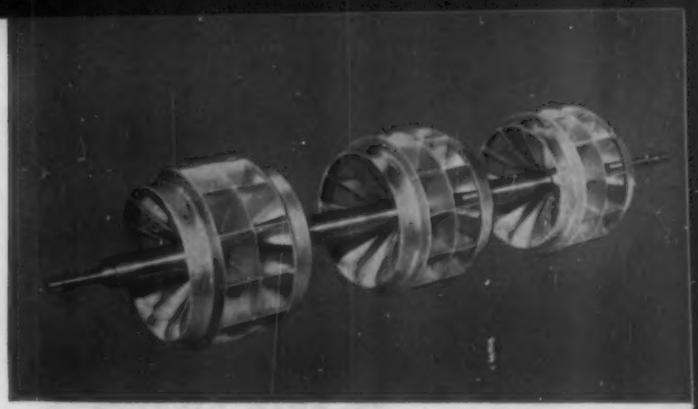
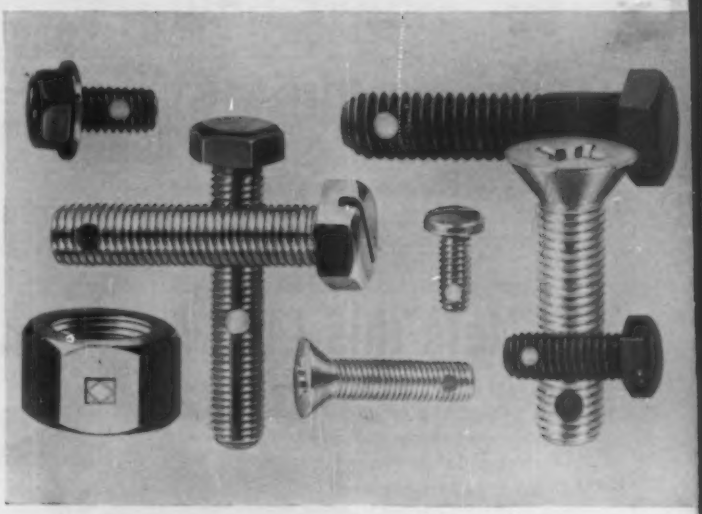
REPUBLIC HS6460 HIGH STRENGTH POWDER. This soft, alloy powder can be used to design and produce higher strength structural parts than ever before achieved with ferrous powders. And, at lower manufacturing costs than obtainable with copper infiltration. HS6460 is capable of a minimum tensile strength of 60,000 psi at 6.4 density as sintered—100,000 psi after heat treatment. Excellent carbon compatibility enhances its ability to be heat treated. Chemical composition, physical properties, and test evaluations on HS6460 are contained in Booklet ADV. 1028. Mail the coupon for your free copy.





REPUBLIC ELECTRUNITE® MECHANICAL TUBING was selected as the optimum design material for rotor shafts in scroll-type blowers manufactured by Buffalo Forge Company. ELECTRUNITE shafts—in sizes 3″ to 3¼″ O.D., 8-gage—are bored at each end and a bearing plug inserted. True concentricity of ELECTRUNITE eliminates the need for surface machining . . . assures careful balance and high operating efficiency at speeds up to 2300 rpm. ELECTRUNITE uniformly requires only .015 stock removal from tube ends for positioning of bearing plugs. Mail the coupon for more data on ELECTRUNITE Mechanical Tubing, carbon or stainless steel.



REPUBLIC NYLOK® SELF-LOCKING FASTENERS provide a single-unit answer to vibration, shock, and tension. A permanent nylon insert forces mating threads together for maximum holding power in any position. The relatively inert nylon resists age and moisture—is unaffected by temperature extremes; its natural resiliency permits easy adjustment and repeated use. Republic Nylok Fasteners are non-galling and require no lubricants. Send coupon for descriptive literature; specify bolts or nuts, or both.

REPUBLIC HIGH STRENGTH STEELS eliminate excessive weight . . . add toughness, resistance to abrasion and corrosion. When mobile equipment is designed and engineered to take full advantage of Republic High Strength Steels, weight savings up to 50% are possible, with no sacrifice of performance or safety. High Strength Steels are produced by Republic in four types—"M", "50", "65", "70"—with minimum yield strengths ranging from 50,000 psi to 70,000 psi, and tensile strengths from 75,000 psi to 90,000 psi. Available in a wide range of sizes in bars, plates, sheets, strip. Mail coupon for literature.

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Send more information on:

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☐ ELECTRUNITE Tubing ☐ Carbon ☐ Stainless
☐ High Strength Steels ☐ "M" ☐ "50" ☐ "65" & "70"

Name_____ Title_____

Company_____

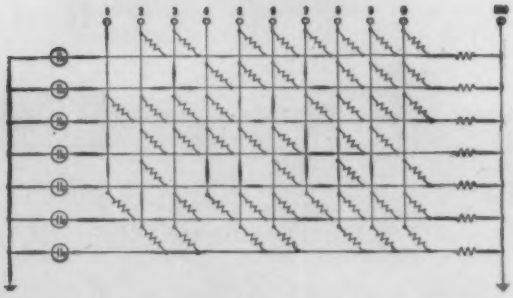
Address_____

City_____ Zone____ State_____

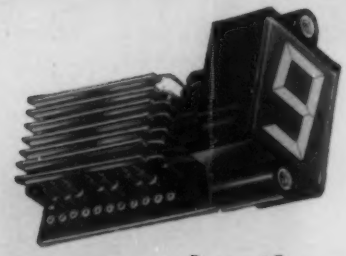
This G-E Glow Lamp...

NE-2E

in this circuit...



lets this I.D.E.A. Readout...



send a message—by the numbers!

Here's the model SGS-101 Digital Readout, made by I.D.E.A. Inc., Indianapolis, Indiana. The numeric readout is accomplished through the use of cut-out lines which, when lighted, give a visual reading of any numeral from "1" through "0". General Electric NE-2E Glow Lamps function as circuit elements in the logic matrix, in addition to providing the illumination on the face of the readout.

Why the G-E NE-2E Was Chosen. The formed-tip construction used on the NE-2E provides better end-on brightness than can be obtained with the random-tipped NE-2 types. Decreased overall length (¾" rather than 1 1/16") also makes the lamp appealing for this application. Since the NE-2E is designed primarily for indicator rather than circuit component usage, lamps are seasoned and selected by I.D.E.A. Inc. before installation in the logic matrix.

The I.D.E.A. Digital Readout is one example of how a General Electric Glow Lamp performs its intended function—and a little bit more. You'll find the same flexibility and dependability in the G-E Glow Lamp you choose for your own circuitry. For latest glow lamp engineering specifications write: General Electric Co., Miniature Lamp Dept. M-013, Nela Park, Cleveland 12, Ohio. Ask for: Specification sheet #3-092 "G-E Glow Lamps for Circuit Component Use".

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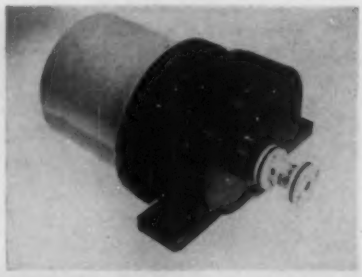
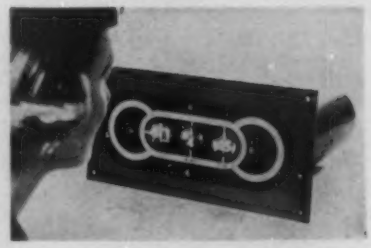
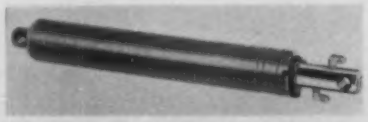
GENERAL ELECTRIC

operations. Janney Cylinder Co, 7401 State Road, Philadelphia. 36.
Circle 316 on Reader Service Card



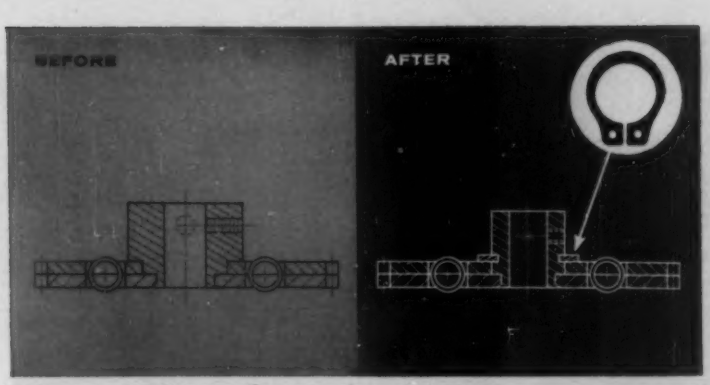


High-speed position indicator system for use in automatically programed machine tools continuously displays location of work through progressive operations for monitoring purposes. In semi-automatic production systems, indicator serves as readout for operator controlling work cycle. System comprises position sensor (top photo) and position indicator (bottom photo). Signals are transmitted electrically to numerical indicator. Standard model reads feet, inches and ⅛ in. through range of 0 to 100 ft. Said to read positions accurately at speeds of 130 fpm and accelerations up to 1 ft per sec². Indicator unit, which may be shelf or panel mounted, has over-all dimensions of 7 x 14 x 10¾ in. Power requirement is less than 40 w, 110 v, 60 cps. Operating range is −67 to 167 F min. Sanders Associates Inc, 95 Canal St, Nashua, NH.
See Booth 2215 or
Circle 317 on Reader Service Card

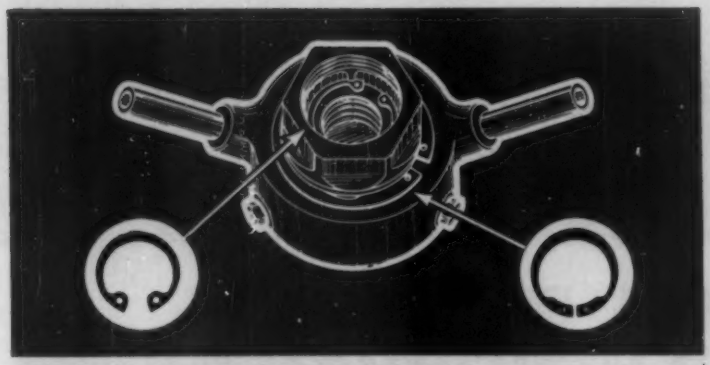


Hollow-rod hydraulic cylinders are two-piece tubular rods that allow oil to flow through rod in two separate channels to operate double-acting cylinders. Cylinder barrel is plain, without port connections, and rod is anchored in stationary

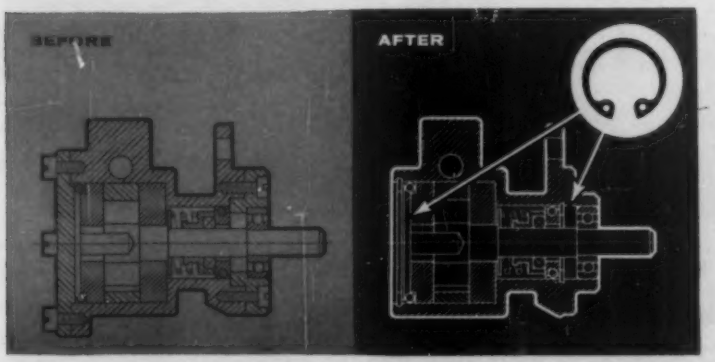
continued on page 186



Gear assembly improved. A Waldes Truarc Series 5100 retaining ring in this anti-backlash gear assembly eliminates machining and staking operations, reduces hub size, and allows easy disassembly, after gears are cut as a unit, for faster, better deburring. Typical savings: $350.00 per 1000 units.



Threaded retainers eliminated. In this self-sealing coupling, costly internal and external threaded retainers were eliminated by easy-to-apply internal (Series 5000) and external (Series 5108) Truarc retaining rings. Savings per unit amounted to $4.02.



End-cover design simplified. In this general-purpose pump, two Waldes Truarc, Series 5000, internal retaining rings make possible the elimination of two cover-plate castings (plus machining) and eight screws (plus drilling and tapping). Weight and dimensions are reduced and assembly and disassembly are greatly facilitated. Typical cost savings: $1.48 per unit.

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WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor Inc., Long Island City 1, N. Y.

Designing for axial assembly with Truarc retaining rings

eliminates parts, machining, speeds assembly, simplifies maintenance

The proper application of retaining rings on or in axial assemblies can often effect startling simplifications and economies in design when compared to corresponding designs with conventional fastening devices. A few typical examples, using basic types of retaining rings, are shown in the accompanying drawings.

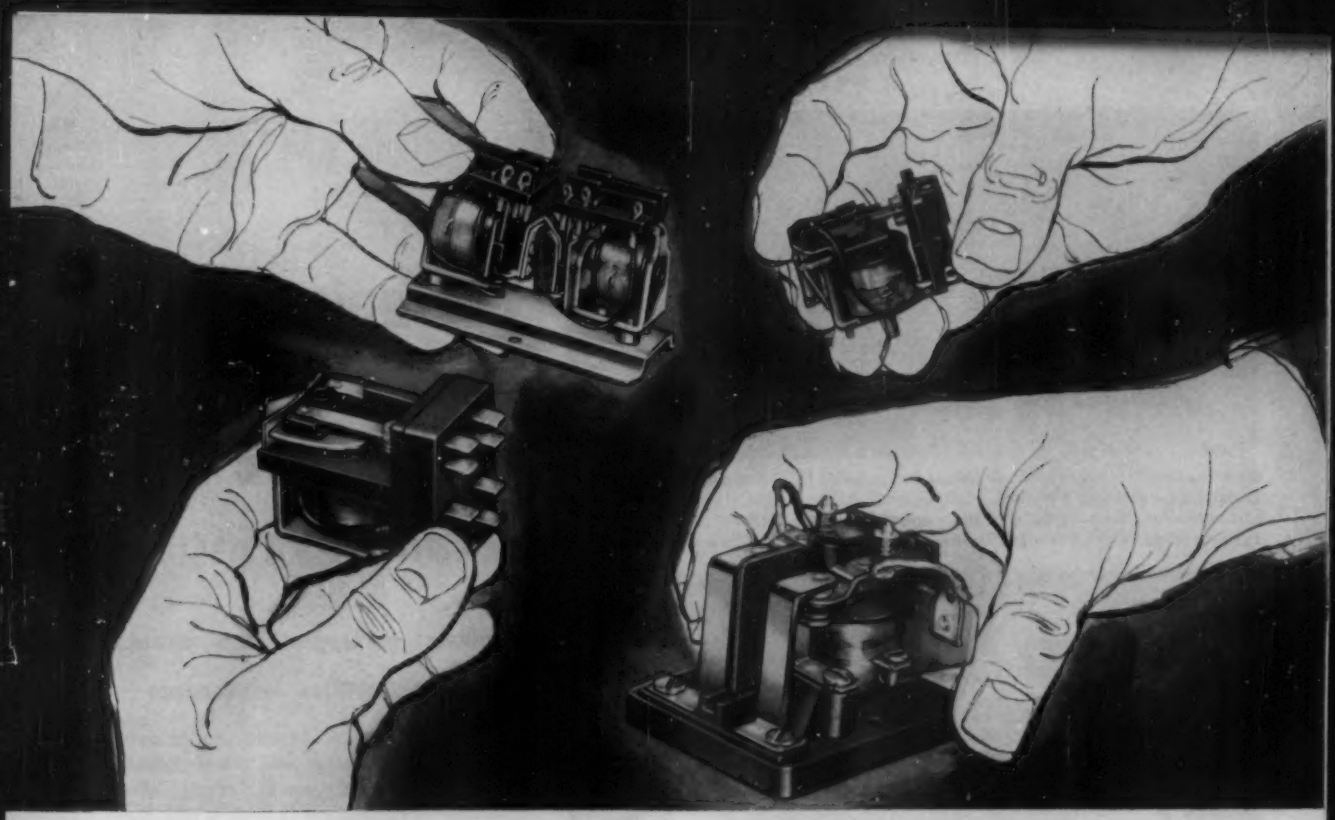
Threading, tapping, drilling, facing and other costly, time-consuming operations can be eliminated. Retaining rings are already in wide use in a tremendous variety of equipment ranging from household products to high-precision military gear designed for use under the most severe environmental conditions. They are quickly and simply installed in easily cut grooves which can often be machined simultaneously with other operations. The rings can frequently replace bulkier, more costly fastening devices—such as nuts, screws, studs, threaded sleeves and retainers, cotter pins, set collars, rivets and machined shoulders.

What's more, rings frequently make practical designs which could be achieved with no other known fastening device.

Although the ring types shown here are basic, Truarc retaining rings come in 50 functionally different types, as many as 97 different sizes within a type, 6 metal specifications and 13 finishes. You'll find detailed descriptions of Truarc retaining rings and assembly tools, plus more than 70 typical applications in the new 24-page catalogue RR10-58. Write for your copy today.

And remember, Waldes engineers are always ready to help you solve your application problems—whether it involves one of the standard Truarc rings or a "special" to fit your particular requirements. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS



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PR Series

Type	Contact Arrangement*	Type	Contact Arrangement*
PR1AY	SPST-NO	PR5AY	SPDT
PR3AY	SPDT-NO-DM	PR7AY	DPST-NO
		PR11AY	DPDT

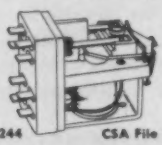
These relays are available in any of the following operating voltages: 6, 12, 24, 115, 230 volts 50/60 cycles AC.

Contacts are rated at: 25 amps, 115/230 V. AC 1 phase. 1 hp for 115/230 volt AC motors 1 phase.

*Read: NO normally open, NC normally closed, DB double break, DM double make.

U/L File E22375 CSA File 15734

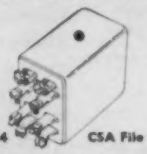
AB Series



U/L File E29244 CSA File 15734

For appliance and general purpose operations requiring long life and quiet operation. Quick connect terminals. Screw terminal adapters also furnished with each relay. Contact arrangement: DPDT. Rated at 10 amps, 115 V., 5 amps, 230 AC non-inductive by U/L and CSA.

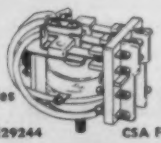
ABC Series



U/L File E29244 CSA File 15734

Medium duty power relay in dust cover. For small motors, industrial controls and similar applications. Contact arrangement: DPDT. Rated at 10 amps, 115 V., 5 amps, 230 AC non-inductive by U/L and CSA.

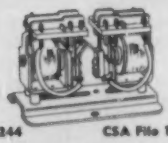
KA Series



U/L File E29244 CSA File 15734

Small, low cost, general purpose relay for handling automation work, small motors, solenoids, other relays. Contact arrangements: SPDT, DPDT and 3PDT. Rated at 5 amps, at 115 V., AC non-inductive by U/L and CSA.

KB Series



U/L File E29244 CSA File 15734

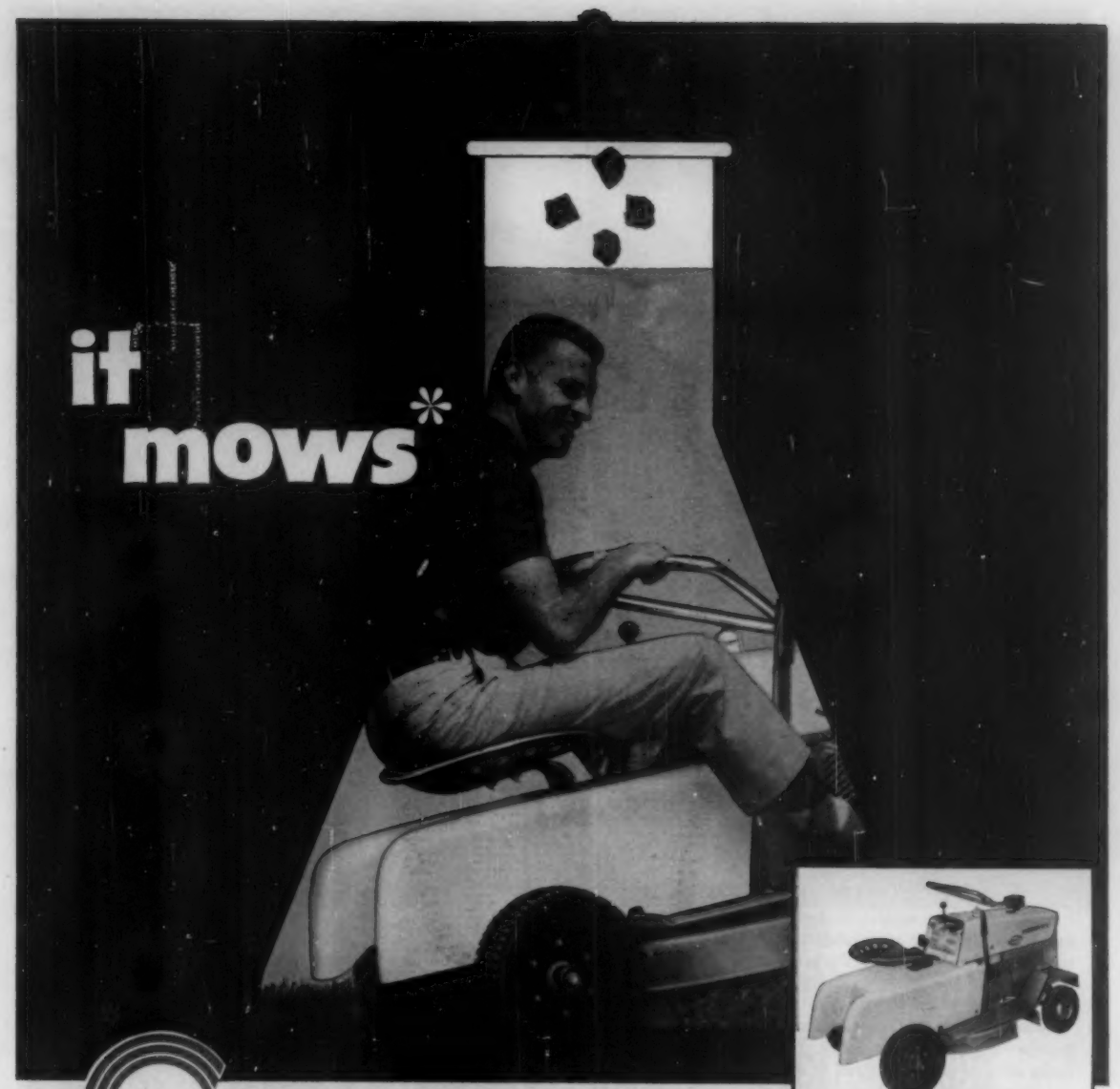
Compact latch relay ideal for memory work and overload applications. Operates on momentary impulse to either coil. Contact arrangements: 4PDT and 6PDT. Rated at 5 amps at 115 V., AC non-inductive by U/L and CSA.

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

CIRCLE 184 ON READER SERVICE CARD



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Homelite Division of Textron Inc. specified CYCOLAC for the body sections of its ride-on lawn mower because this lightweight, ABS material was the one plastic that offered the rugged durability required by such outdoor equipment. With the high impact strength of CYCOLAC, the body is protected against damage from knocks and blows. In addition, CYCOLAC eliminates corrosion and staining, insuring a mower body that will retain its attractive, glossy appearance. Because of its unique combination of properties, CYCOLAC can be used for many products formerly made of metal—at substantial savings. It may be the material that will make **your** product more profitable. Why not discuss this with one of our representatives? Write today.

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DIVISION **BORG-WARNER** WEST VIRGINIA

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Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66DD.

Design Show Booth 516

DUFF-NORTON COMPANY

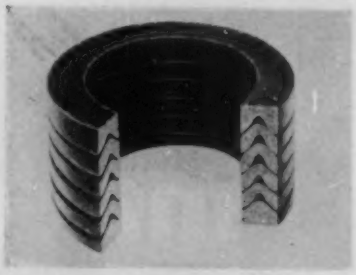
P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

position. Barrel is reciprocating member. Hydraulic-line connections to cylinder barrel are also eliminated through use of hollow-rod cylinder. Benton Harbor Engineering Works Inc, 622 Langley Ave, St Joseph, Mich. See Booth 1635 or
Circle 318 on Reader Service Card



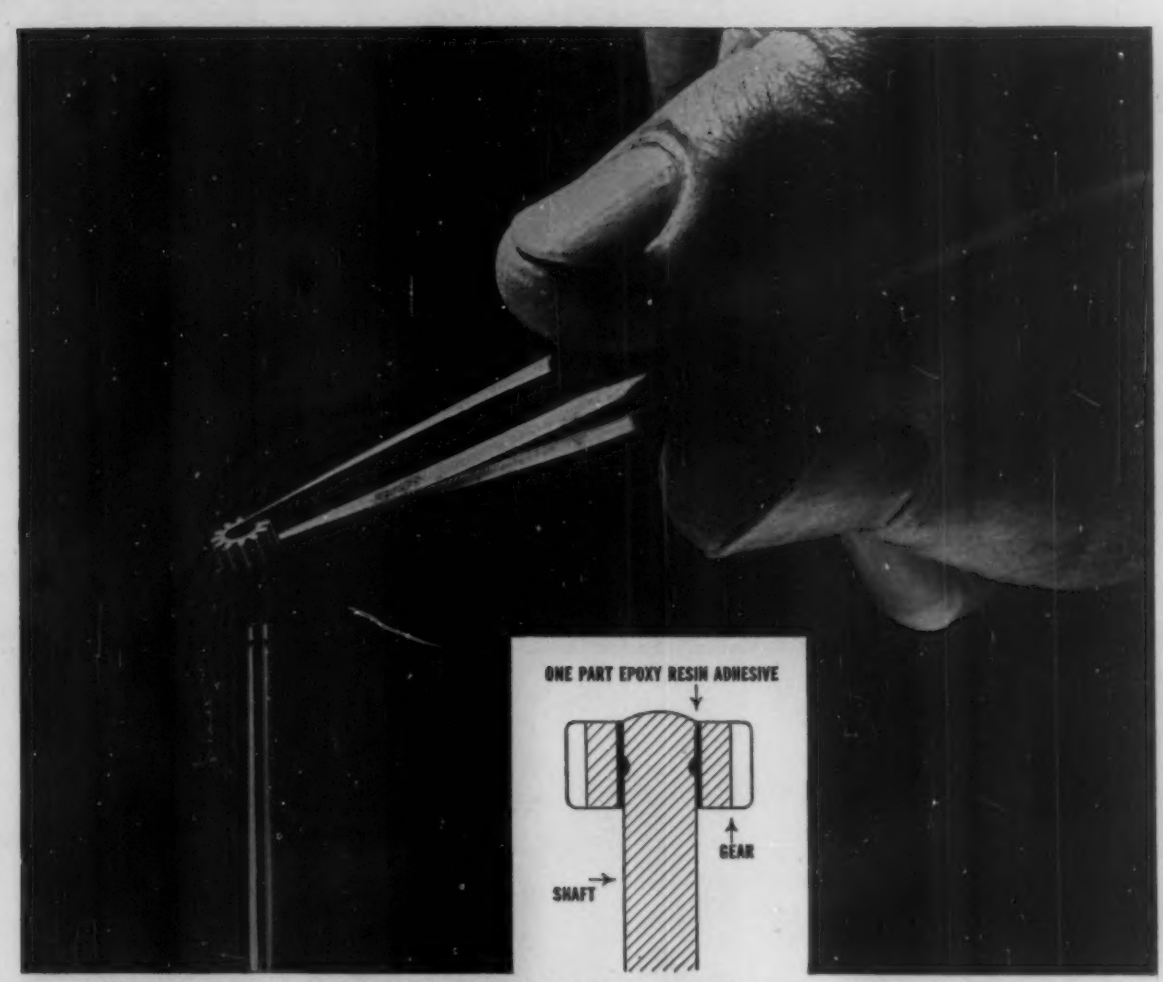
Molded packings . . .

for all hydraulic and pneumatic equipment are made of Teflon-impregnated asbestos fabric. Self-sealing, self-adjusting packing rings (top photo) tolerate gland pressure without creating corresponding excessive friction and extrusion. Hydraulic or gas pressure automatically expands lip or circumference of rings on pressure stroke, forming tight seal against stuffing-box wall or shaft. Rings nest together in sets. Piston cups (bottom photo) are said to provide negligible friction at all pressures, resistance to extrusion, dimensional uniformity and max sealing efficiency. Reported to eliminate failure in tension at base of cup because of high friction at sealing surface. Packings can be used in temperatures to 500 F. Packing rings are available for spaces from $\frac{1}{4}$ through $\frac{7}{8}$ in. Raybestos-Manhattan Inc, Packing Div, Passaic, NJ. See Booths 1810 - 1812 or
Circle 319 on Reader Service Card

Self-clinching fastener

include unit (illustrated) for providing load-bearing threads in metal sheets said to be too thin to thread, with captive floating nut permitting up to $\frac{1}{32}$-in. adjustment to compensate for slightly off-center holes

continued on page 188



See us at the Design Engineering Show, New York Coliseum, New York City, May 23 through May 26. Booths 1718-1720.

How fabricating with SCOTCH-WELD® BRAND Structural Adhesives eliminated 100% inspection step

Timing components now being fabricated with SCOTCH-WELD Adhesive EC-1386 meet precise specifications. The Haydon Division, General Time Corp., Torrington, Conn., is using this one-part epoxy resin base adhesive to bond small pinion gears to rotor shafts in a sub-assembly timing gear operation.

Prior to use of EC-1386, the parts were joined by brazing. But the high heat required affected the material hardness. It also produced shaft distortion, necessitating a 100% inspection step.

Then SCOTCH-WELD Adhesive EC-1386 was used. The high heat previously required was eliminated. With the end of this trouble source, shaft concentricity and material hardness were left unaffected, the 100% inspection eliminated. Close tolerance requirements between shaft and gear were also eliminated because of void-filling properties of the adhesive. A savings of $56.37 per thousand assemblies resulted.

Company after company is discovering how to save money, speed production and eliminate rejects by using SCOTCH-WELD Structural Adhesives in the fabrication of their products. Perhaps these adhesives are at work right now in operations similar to yours. Find out! For free literature without obligation, write today on your company letterhead to: AC&S Division, 3M Company, Dept. SBS-50, St. Paul 6, Minnesota. "SCOTCH-WELD" is a Reg. T.M. of 3M Co.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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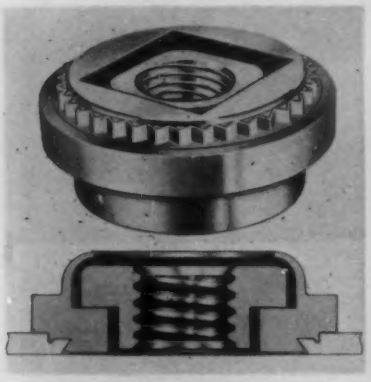
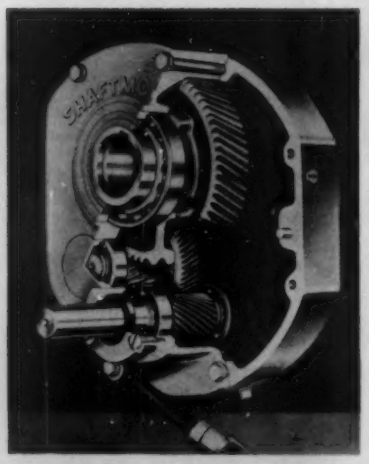


in mating attachment. Made of carbon steel with cadmium plate on basket and cadmium-plated chrome dipped nut. Suitable for materials with Rockwell hardness less than B-70 and sheet thicknesses from 0.040 in. up. Offered in thread sizes from 4 to 10.

Second fastener provides load-bearing threads in sheetmetal of thicknesses down to 0.032 in. and with Rockwell hardness of B-70 or less. Installed by standard pneumatic or oil-hydraulic squeezer into previously punched or drilled holes. Said to have high pushout and torque resistance. Does not project on reverse side of sheet. Made in carbon steel and 303 stainless steel with thread sizes from 0 to 3. From stock. **Penn Engineering & Mfg Corp, Doylestown, Penna.** See Booth 1023 or

Circle 320 on Reader Service Card



Direct-mounting speed reducer is offered in sizes covering ¼ to 40 hp in speeds from 125 to 5 rpm. Two ratios, 15:1 or 24:1, are available. Enclosed in cast-iron case. Heat-treated castings are said to prevent warp or stress. Mounts in choice of positions. Oil seal cap has been designed so that it can be replaced without disassembly unit. **US Electrical Motors Inc, Box 2058 Terminal Annex, Los Angeles 54.** See Booths 1704, 1706 or

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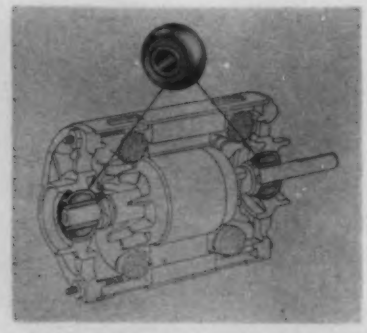


Self-aligning midget bearing is available for shaft sizes of ⅛, 1/16, ¾ and 1/16 in. Permanently lubricated bearing has sintered bronze bushing. Supplied to standard industry tolerances. Applicable to small fhp motors. **Randall Graphite Bearings Inc, Greenlawn Ave, Lima, Ohio.**

See Booth 914 or

Circle 322 on Reader Service Card

Fan-cooled speed reducers . . . are reported capable of transmitting up to 80% more horsepower than conventional worm gear units. Centrifugally cast bronze gears and heat-treated alloy steel worms combine with fan-cooling to permit higher input horsepower and output torque ratings with smaller units. **Cleveland Worm & Gear Co, 3249 E 80th St, Cleveland 4.**

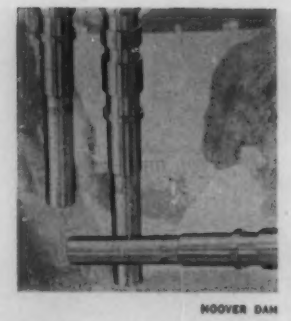
See Booth 1337 or

Circle 323 on Reader Service Card

1-part fluid silicone rubber . . . requires no premixing, and cures or vulcanizes at room temperature. Samples of RTV 731 are available for testing and evaluation at the Design Show, or write on company letterhead. **Dow Corning Corp, Midland, Mich.** See Booth 1915 or

Circle 324 on Reader Service Card

continued on page 192



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At the Design Show... Booth 1504

Working Models On Display

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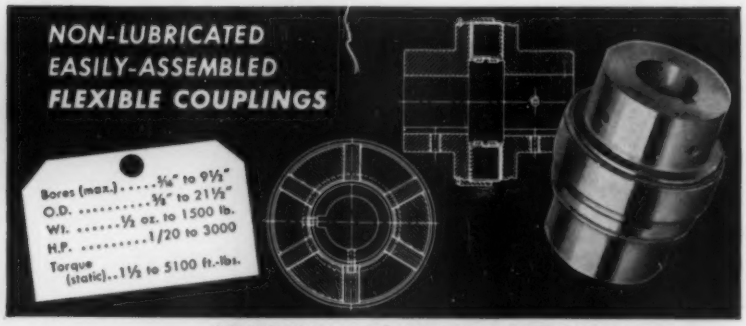
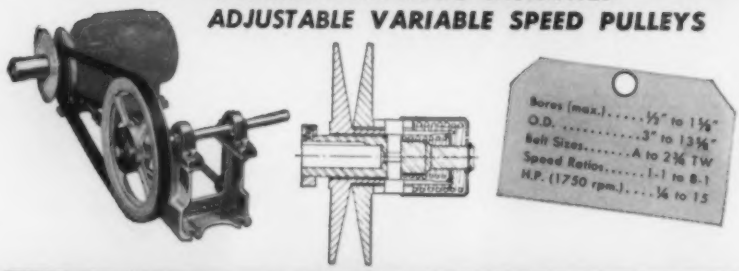
Yours for the asking, this literature gives a wealth of valuable information on power transmission equipment in easy-to-read, easy-to-file form.



LOVEJOY and HI-LO INSTANTLY-ADJUSTABLE VARIABLE SPEED PULLEYS



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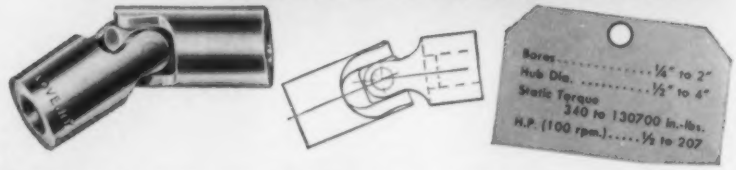

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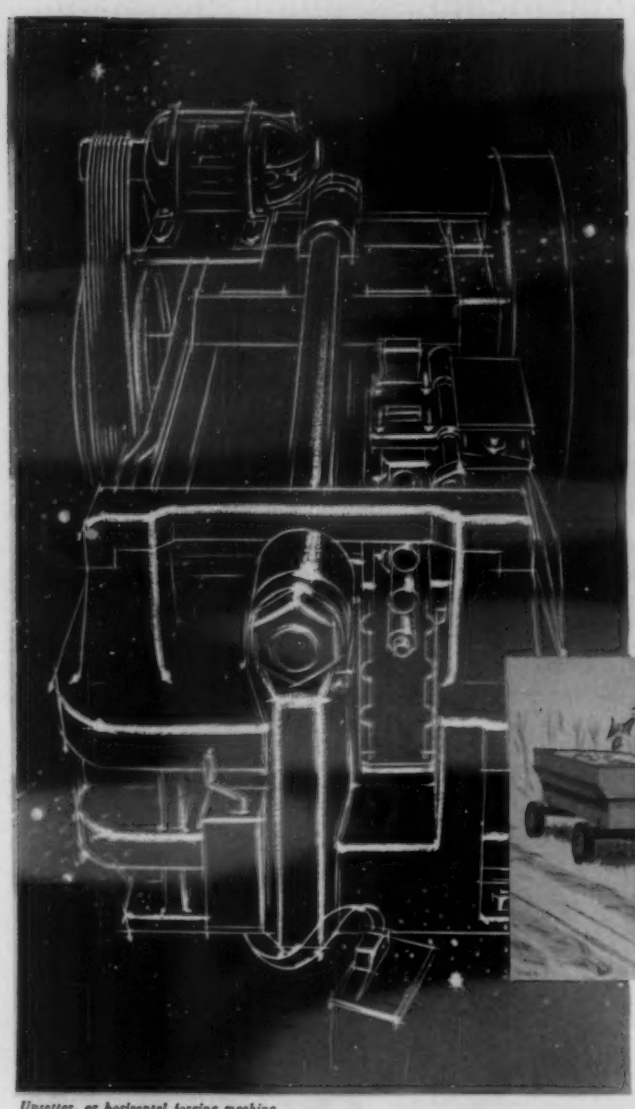

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SEE THE WHOLE STORY OF FORGINGS
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- Sizes from ¼" to 1½" diameters.

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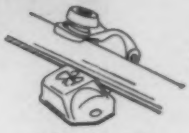


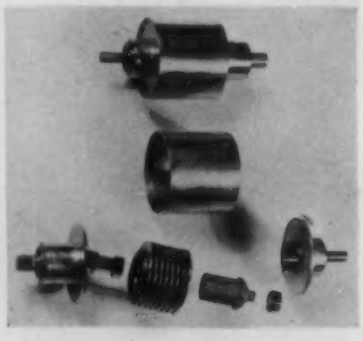
CLOSE HINGED RETAINER

LOCK TIGHT WITH A ¼ TURN

CAMLOC®

"Specialists in Fasteners for Industry"

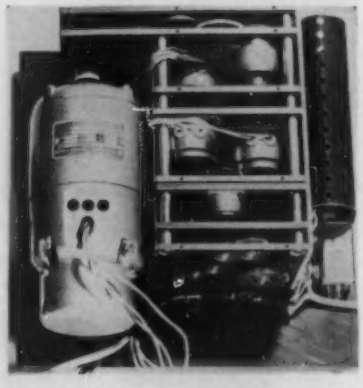
CAMLOC FASTENER CORPORATION
62 SPRING VALLEY ROAD • PARAMUS, N. J.
WEST COAST OFFICE: 5410 Wilshire Boulevard, Los Angeles, California
SOUTH WEST OFFICE: 2509 West Berry Street, Fort Worth, Texas



Rotary hermetic seal uses bellows . . .

that changes rotary motion into nutating motion and back to rotary; was originally designed to transmit rotational motion to airborne computer elements inside a sealed case. Input shaft retains a canted shaft inside unit's bellows. Bearing cup is positioned over two bearings on canted shaft. This cup is soldered to bellows, which in turn is soldered to inside of seal housing. Canted shaft rotating in bearing cup causes nutating motion in bellows, which does not rotate. Standard unit is 0.950 in. dia. and sells for about $30. Can be made with 0.500-in. dia, and also larger than standard. Backlash is less than 5°, and leak rate is guaranteed to be less than 10^{-6} cc per sec. **Licon Div, Illinois Tool Works, 6606 W Dakin St, Chicago 34.**

See Booths 1629-31 or
Circle 325 on Reader Service Card



Redesigned miniature transmission . . .

with Delrin gears offers range of 15 speeds, from 3.3 to 7812 rpm. Speeds, said to be exact, are electronically controlled by magnetic clutches. Desired rpm is obtained by dialing—eliminating manual shifting of gears. More than half of gears used in transmission are Delrin; others are either 303 stainless steel or 24 ST aluminum. All shafts are 303 stainless. At 7812 rpm,

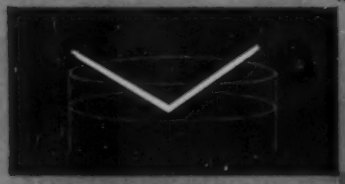
continued on page 196

Announcing
Infrabeam
... the revolutionary photoelectric control using modulated infrared radiation

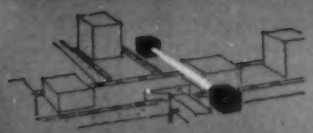
Model 9101

LONG-RANGE DETECTION

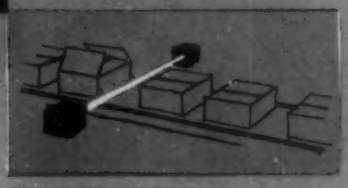
MACHINE CONTROL



LIQUID LEVEL CONTROL



INSPECTION OR SORTING



CONVEYOR CONTROL

FOR THE FIRST TIME, photoelectric control is *simple, reliable,* and *practical* over an extremely wide range of applications.

Infrabeam is a totally new type of photoelectric control . . . developed and tested over a period of more than a year, now ready to go to work in your plant or as part of equipment you manufacture. It offers a combination of simplicity, sensitiveness and reliability that has never before been achieved.

New infrared detectors, perfected for missile guidance, are in many ways superior to photocells that respond to visible or ultraviolet light. In Infrabeam, the Receiver contains a similar infrared detector which is screened against visible light by a simple optical filter. Further, the infrared beam from the Projector is "modulated" — brightening and dimming at a frequency of 400 cycles per second. The Receiver is electronically tuned to this frequency, so that the control will not respond unless it gets a signal from the associated Projector.

WHAT THIS MEANS TO YOU . . .

Compared with standard "general purpose" photoelectric controls, Infrabeam provides far greater sensitiveness in countless applications at close or moderate range. At extreme range — as much as 1000 feet — it offers superior reliability and freedom from interference. Because it operates equally well by reflecting the infrared beam from a detected object and into the Receiver, it is the *only* photoelectric control able to reach into "blind" areas with perfect freedom of installation.

Projector and Receiver are attractively housed in anodized cast aluminum. The quick-detach hinge allows easy separation for use as opposed units, or accurate angling for use in reflection. Physical mounting and electrical connections are simplicity itself, and permit quick replacement of either unit without disturbing permanent wiring.

Find out how simple and practical photoelectric control can be for *you.* WRITE TODAY FOR COMPLETE DETAILS AND SPECIFICATIONS.

ELECTRONICS DIVISION

CRAMER CONTROLS

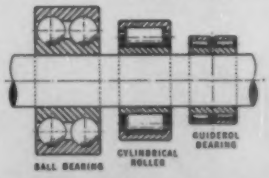
CORPORATION

CENTERBROOK, CONNECTICUT

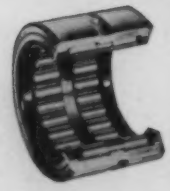
McGILL®

GUIDEROL® bearings offer higher load

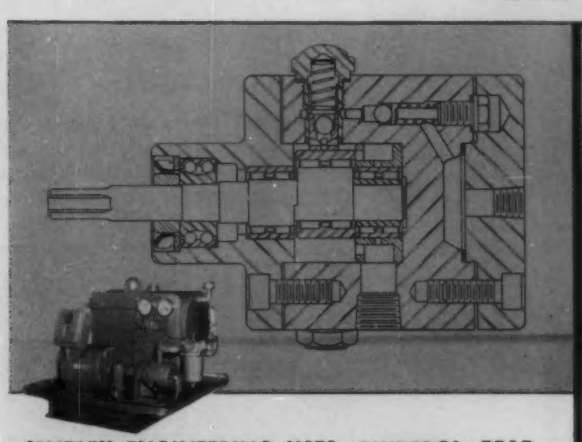
GUIDEROL bearings pack more high capacity performance into smaller radial space. Their construction features the extra capacity of a full complement needle bearing and effective roller control. Center guided rollers limit skewing and prevent binding under adverse conditions in either horizontal or vertical mountings. For a common 1" shaft, the GUIDEROL bearing has an O.D. of only 1½" with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing, the GUIDEROL bearing requires ⅜" less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load. Space-saving GUIDEROL bearings simplify design and cut housing space requirements. Available with or without inner rings in shaft sizes from ⅜" to 9¼" with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).



Sealed Guiderol Bearings Protect Performance Life and Cut Maintenance



Pre-lubricated and sealed GUIDEROL bearings lock lubrication in and seal contamination out. Interchangeable dimensionally with GUIDEROL GR Series bearings, they cut maintenance in two ways. Bearings last longer and frequent re-lubrication is not required. 5 different seal combinations are available to fit specific mounting requirements.

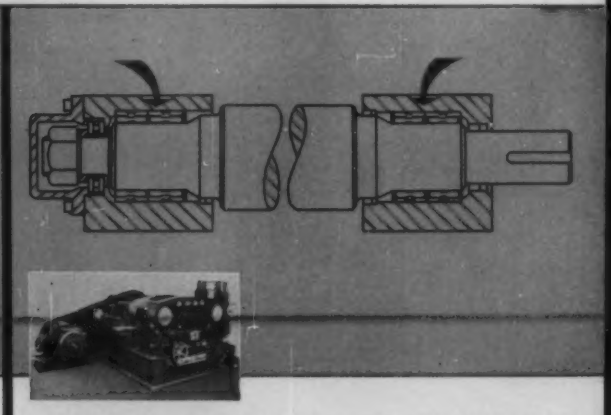


SIMPLEX ENGINEERING USES GUIDEROL BEARINGS IN HIGH PRESSURE HYDRAULIC PUMPS

The SECO "LA" Series pumps, shown in cross section above, are fixed displacement seven piston radial pumps, utilizing unique patented principles which enable them to generate pressures as high as 10,000 PSI without loss of mechanical efficiency. SECO pumps are manufactured by the SIMPLEX ENGINEERING COMPANY, a subsidiary of RACINE HYDRAULICS & MACHINERY, INC.

McGILL GUIDEROL MT Series bearings are used as shaft support bearings, and center eccentric floating bearings in these and other series Simplex pumps.

SIMPLEX reports unusual success with heavier loads and most satisfactory bearing life through ten years of use of McGILL bearings. They have helped to produce the strikingly long life for which these pumps have become famous.



KANE AND ROACH LEVELER SHAFTS ROLL ON GUIDEROL BEARINGS

Kane and Roach depends on 26 matched pairs of GUIDEROL bearings to carry the leveling and flat straightening loads resulting from rolling alloy steels of 80,000 PSI yield. They are used on K & R No. 7 Levelers as roll neck bearings on the 11 power driven main leveler shafts and on the pair of adjustable pinch roll shafts that guide entry of alloy steel bars up to 1" thick by 8" wide.

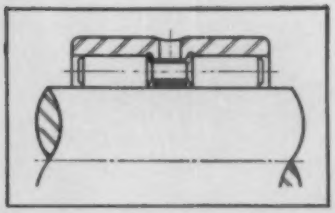
Shown are the matched GUIDEROL bearings in their roll neck mountings. Driven through universal joints at 38 to 114 RPM, the power rollers, supported at each end by pressure lubricated GUIDEROL bearings, provide production speeds of 70 to 210 feet per minute.

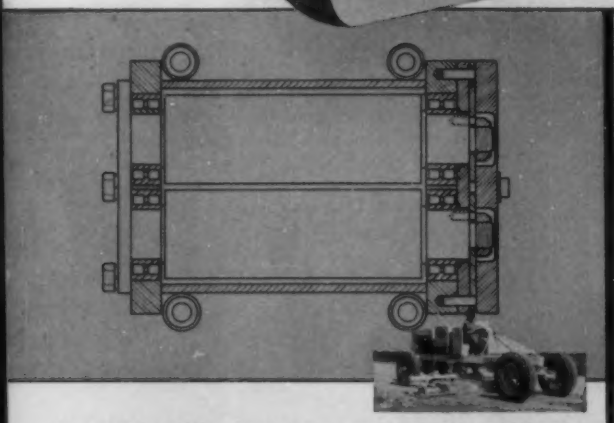
Kane and Roach uses GUIDEROL bearings in many applications with complete assurance of extra capacity and dependable performance with minimum maintenance.

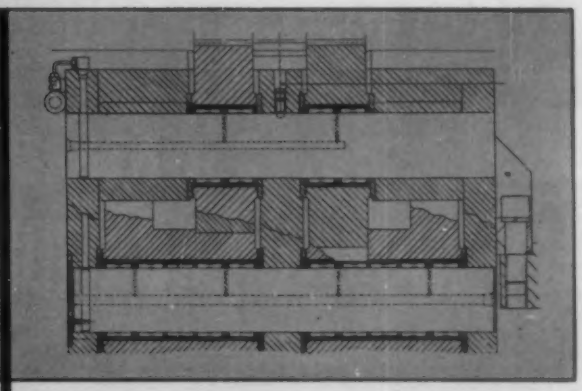
WRITE TODAY FOR FREE McGILL BEARING CATALOG No. 52-A for complete data on McGILL GUIDEROL, CAMROL, MULTIROL and CAGEROL BEARINGS.

capacity in smaller radial space

GUIDEROL BEARING
Cutaway to show center guided roller principle







GUIDEROL BEARINGS WITHSTAND VIBRATION IN LIMA ROADPACKER APPLICATION

GUIDEROL bearings support the off-balance rotors which produce vertical vibration in the six vibrator assemblies of each LIMA ROADPACKER machine. The drawing shows the position of 4 rotor support bearings. A gear motor drives the rotors which are one-half filled with lead to produce vibration for road compacting.

The user states that GUIDEROL bearings were selected because of high capacity in limited diameter and their ability to withstand extensive off-balance vibration. Possible end floating of the separable bearing fits the design very nicely. Performance is considered most satisfactory as the bearings easily resist the eccentric loading.

GIDDINGS & LEWIS SKIN MILLING MACHINE APPLICATION REQUIRES GUIDEROL RIGIDITY — MINIMUM DEFLECTION

GUIDEROL BEARINGS, IN MATCHED SETS are used to mount the reduction gearing in the table drive gear box of each NUMERCOID tape controlled skin milling machine. The drawing shows a partial section of the table drive. GIDDINGS & LEWIS MACHINE TOOL CO. cites excellent performance of the GUIDEROL bearings. Guided rollers in this bearing have eliminated the problem of having the roller bind on the shaft if slight misalignment is present. The drive assembly mechanism reduces back lash by using a pre-loaded gear arrangement and matched bearings. The bearings are flooded with oil through the center of the shaft. Speeds are 1/30 to 460 RPM.

engineered electrical products

McGILL®

precision needle roller bearings

MULTIROL-GUIDEROL-CAMROL-CAGEROL

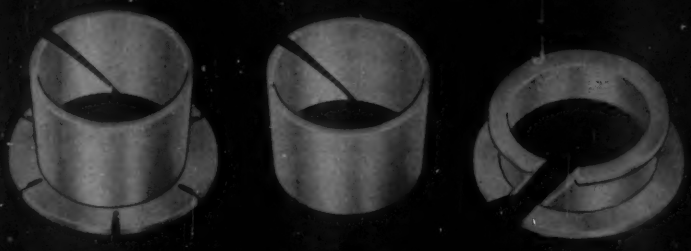
McGILL MANUFACTURING CO., INC., Bearing Div.,
201 N. Lafayette St., Valparaiso, Ind.

CIRCLE 195 ON READER SERVICE CARD 195

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS®

–*BEARINGS of smooth, tough DuPont* NYLON



Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

COST LESS to BUY
COST LESS to INSTALL
& ELIMINATE LUBRICATION

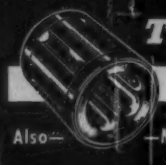
Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.



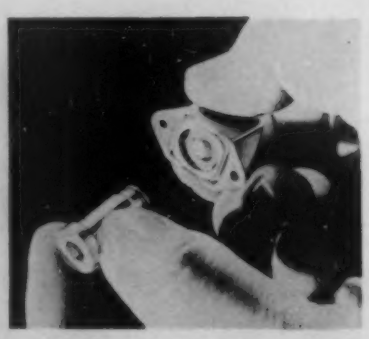
THOMSON INDUSTRIES, Inc.

DEPT. 11, MANHASSET, NEW YORK

Also— –Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

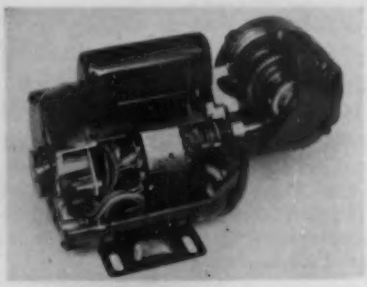
transmission develops over ¼ hp. Torque developed is over 100 in.-oz, depending upon speed. Case dimensions, excluding power source and control panel, are 4¼ x 7¼ x 3⅜ in. high. Input motor is reversible and delivers above-mentioned speeds and respective torque in either direction. Motor speed is self-governed and accurately maintained at 8500 rpm. Units operate on 115 v, 60 cps. **Dynamic Gear Co Inc, Dixon Ave, Amityville, NY.**

See Booth 1104 or
Circle 326 on Reader Service Card



Stressed panel fastener . . .
is suited for applications requiring a combination of high load-carrying capabilities and ease of access. Serrated mating faces are said to provide 100% locking in any position. **Deutsch Fastener Corp, PO Box 61072, Los Angeles 61.**

See Booth 315 or
Circle 327 on Reader Service Card



Right-angle gearmotor . . .
has worm gear of silicon bronze, and worm made of hardened steel. Cutaway view is of single reduction 48-frame unit. Face-type seal with spring back is used on high-speed shaft, and lip-type seal is used on low-speed shaft to keep oil from getting into motor. All-angle oiling is possible with worm gear always dipping into oil for continuous lubrication.

Also to be featured at Design Show is selective-speed drive unit available in 1- to 15-hp ratings. Includes thyratron exciter

continued on page 200

Alcoa puts the metal where you want it

How BIG an impact have you seen lately? Alcoa can now make them up to 12 in. in diameter and 60 in. long.

When Alcoa's new 2,500-ton press hits an aluminum alloy slug, a giant impact is formed with the combined strength of an extrusion and forging.

Like their small brothers, these big new impacts can save you money. They are produced in one fast operation. There's no parting line to be ground. No scale to be removed. No draft to be cut off. Impacts have forged bases and extruded sections. Multiple parts can often be combined into one integral impact eliminating welded or mechanical joints. Machining is reduced, and excessive material waste is eliminated.

You can get these big new Alcoa® Impacts in many alloys with tensile strengths up to 75,000 psi. Also made from aluminum powder metallurgy alloys which provide excellent properties at elevated temperatures.

Alcoa Impacts are unfailingly sound. They have smooth, corrosion-resistant surfaces. You can have them in plain or complex shapes with design features combining those of forgings and extrusions—flanges, steps, multiple walls, bosses, ribs.

In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where you want it. A call to Alcoa can mean ingenious design solutions. Start now; write for *Metal in Motion*, Alcoa's new 34-page brochure on impacts. Aluminum Company of America, 908-D Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

Alcoa puts the metal where you want it . . . in impacts, castings, forgings, extrusions and screw machine parts.

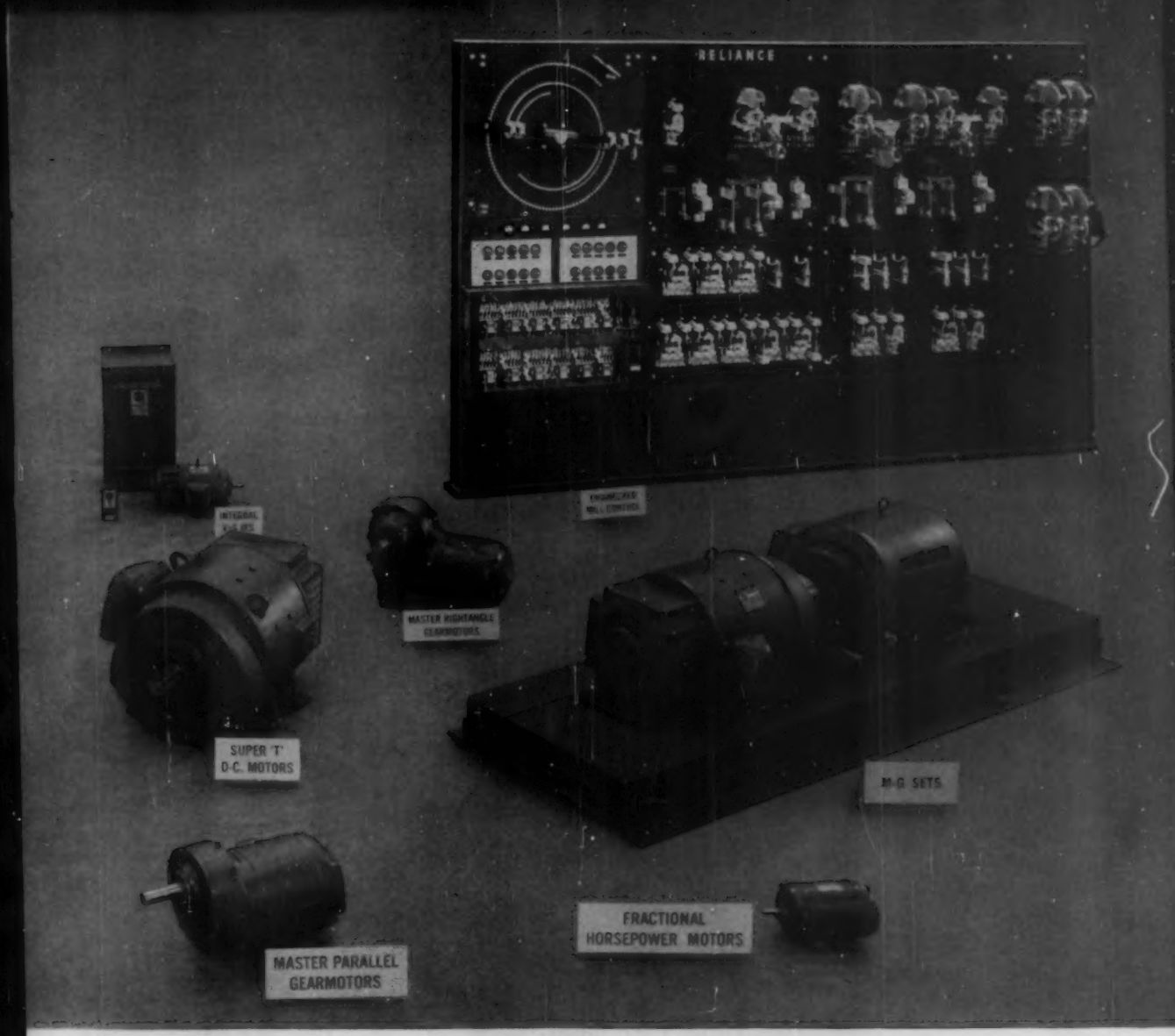
VISIT ALCOA'S BOOTH AT THE DESIGN SHOW, MAY 23-26 . . . BOOTH NO. 2032

C. V. Gregory, General Sales Manager, Reliance Electric and Engineering Co.

Pinpoint the *exact* drive for your

C. V. Gregory makes sure you get that exact drive. His Reliance Sales Engineers provide the application experience to make it easy for you to select from this full line of mechanical and electrical drives . . . ⅛ to 1,000 horsepower.

From silo unloaders and barn cleaners to the most completely automated industrial machinery, Reliance motors and drive systems provide just the right motive power.



A-1007

machine from Reliance's full line

Get proof of Reliance's sound product engineering and performance. Talk to a Reliance Sales Engineer. There is an office near you. Check the Yellow Pages or write for Catalog A-100 showing the Reliance full line.

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

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Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

See Reliance in booth 2023, Design Engineering Show, New York Coliseum, May 23-26.

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Entire drawing is brought within easy working range on a movable endless belt.

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1960 DESIGN ENGINEERING SHOW

MAY 23-26

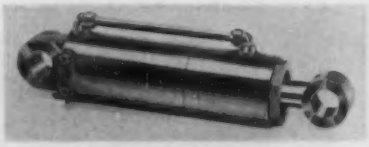
NEW YORK COLISEUM

GENERAL FIREPROOFING

BUSINESS FURNITURE

YOUNGSTOWN 1, OHIO

instead of magnetic amplifier exciter. Century Electric Co, 18th and Pine Sts, St Louis 3. See Booth 1537 or
Circle 328 on Reader Service Card

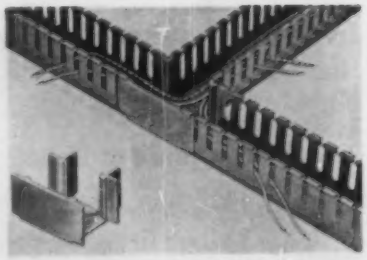


Dual-pilot checkvalve . . .

on double-acting cylinder locks piston rod in any position when directional control valve is in neutral. Incorporated in cylinder head as safety measure where drift is dangerous or undesirable, design is said to simplify hydraulic line circuitry by eliminating separate pilot-operated checkvalves, connections and lines. Available on cylinders in most standard designs and sizes for use in double-acting cylinder applications such as tilting, positioning, and outriggers. Benton Harbor Engineering Works Inc, 622 Langley Ave, St Joseph, Mich.
See Booth 1635 or
Circle 329 on Reader Service Card

Large, hollow-plastic extrusions . . .

are now possible with extrusion technique developed by this company. Process is applicable to ducts, dispensing displays and containers where more than one height is required. In latter case, a single tooling cost for extrusion plus single injection mold for base and cover are all that is required for series of containers. Anchor Plastics Co, 36-36 36th St, Long Island City 6, NY. See Booth 2103 or
Circle 330 on Reader Service Card



Prefab corner and T-fittings . . .

can be assembled with plastic wiring duct. Side flanges allow ¾-in. deviation in duct length. Self-locking duct snaps into place. Sections support themselves rigidly and need not be mounted independently. Fittings are also compatible with snap slot, open slot or wire hole duct designs in any

continued on page 204

The Prime Mover Company, manufacturer of materials handling equipment, says:

Our "Prime Movers" give these 6 parts a terrific beating...that's why they're made of LaSalle

Engineers of the Prime Mover Company, Muscatine, Iowa, demanded the most dependable steel bars available for six important parts of their transmission assembly. Here are some of the reasons they specified STRESSPROOF!

You don't have to heat treat STRESSPROOF! There's no heat treat distortion.

STRESSPROOF is strong . . . 100,000 psi.

It machines faster . . . at 83% the speed of B1112.

It wears better without case hardening . . . replacing .40 carbon alloy steels and other heat treated and alloy steels, such as 8640, 4140, C1045, C1141, and C1137.

It costs less than heat treated in-the-bar alloys.

STRESSPROOF®
STEEL BARS

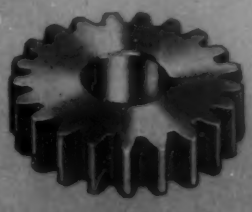
with copper
Strength Without Heat Treating

Worm Shaft, 1½"

Input Shaft, 1 9/32"

Driving Axle, 1 9/32"

Shifting Shaft, ¾"


Reverse Pinion, 3"

Bearing Carrier
Clutch Throwout, 2¼"

Use this coupon to request technical bulletin announcing improvements in LaSalle STRESSPROOF Steel Bars...with copper.

LaSalle STEEL CO.

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Please send technical bulletin "Today's Improved LaSalle STRESSPROOF Steel Bars...with Copper."

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Title_____

Company_____

Address_____

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CIRCLE 201 ON READER SERVICE CARD

CIRCLE 202 ON READER SERVICE CARD →

DELROYD

WORM GEAR SETS

Check these advantages:

- Involute helicoid thread form (strongest thread form made)
- Centrifugally cast gears
- More horsepower per dollar

Delroyd units are manufactured in a modern plant devoted specifically to the production of worm gearing—a plant which has one of the largest thread milling and thread grinding capacities in the United States. Because we use this exclusive precision machinery, the most exacting testing techniques and highly skilled workmanship, you are assured of quality and service associated with the leading specialists in worm gearing.

Delroyd provides the widest range of sizes and ratios, and offers complete interchangeability of parts. Whether you specify worm gear sets or worm gear speed reducers, you are assured of the finest quality obtainable.

DE LAVAL *Steam Turbine Company*

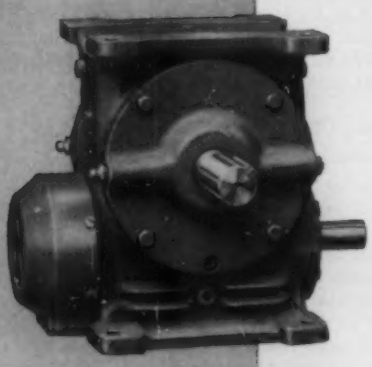
501 NOTTINGHAM WAY, TRENTON 2, N. J.

DELROYD

WORM GEAR SPEED REDUCERS

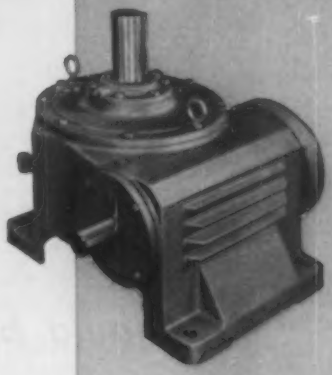
FAN COOLED RIBBED CASES

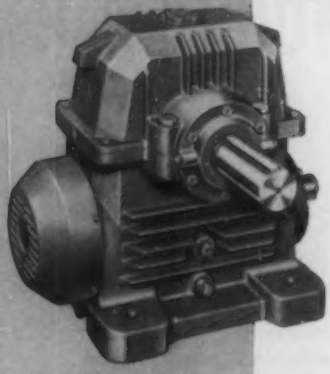
Widest range of ratings available—from .05 HP, 1⅛" center distance to 1050 HP, 36" center distance—in single and double reduction units



TYPE D
Verso Unit
Adapts to any mounting requirement
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 13.5
Center distance:
2½" to 4"

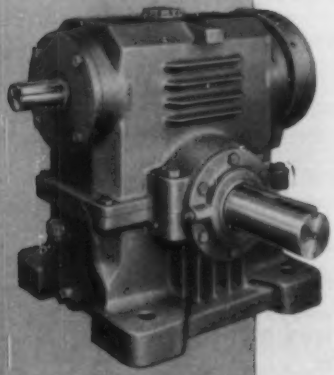
TYPE V
Vertical single reduction
Shaft up or down
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"





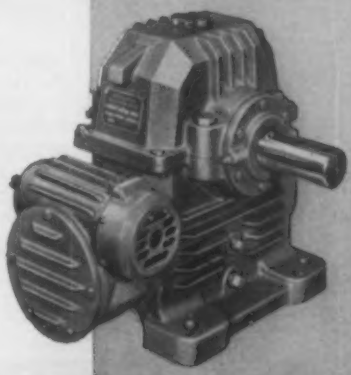
TYPE B
Horizontal single reduction
Bottom drive
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

TYPE HB
Horizontal helical-worm
Right angle drive
Ratios:
15:1 to 355:1
Output torque:
2460 in. lbs. to 135000 in. lbs.
Center distance:
3½" to 12"



TYPE T
Horizontal single reduction
Top drive
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

TYPE DB
Horizontal double-worm
Parallel input and output shafts
Ratios:
75:1 to 4900:1
Output torque:
4170 in. lbs. to 135000 in. lbs.
Center distance:
3½" to 12"



Prompt delivery from stock—all units through 12 inch center distance

DE LAVAL *Steam Turbine Company*

801 NOTTINGHAM WAY, TRENTON 2, N. J.

Why "MARK-TIME" MECHANICAL TIMERS *should be INVESTIGATED!*

Low cost mechanical Timers, Time Switches and Time Devices **can** be quite sophisticated. For example: they can be designed to ring bells, flash lights, turn valves, cut cords, start, stop or operate electrical or mechanical equipment, and to do all this **after** a pre-selected time period has elapsed.

The "Mark-Time" mechanical "memory" **cannot** fail due to an electrical failure since it is spring powered.

The "HEART" of the "Mark-Time" is of a new super-tough alloy which prolongs mainspring life indefinitely.

This new special steel virtually **eliminates** mainspring failure. This adds extra sales features to your product at no extra cost.

The "MARK-TIME" Mainspring is Unbreakable!

Tensile strength, durability and corrosive resistance is unexcelled. No other Timer on the market has these exclusive features.

At present, we manufacture more than 3,000 DIFFERENT kinds of custom-built timers for industrial, consumer and military applications. Thus, we are the **largest** manufacturer of mechanical timers in the **world**!

Research and development work welcome—small runs our specialty.

Sales engineers in 27 key cities at **your** service.

Write for your copy of this **new** Engineering Handbook on Timers, specifically written and illustrated for the Design and Development Engineer.

MARK-TIME

M. H. RHODES, inc.

HARTFORD 5, CONNECTICUT

IN CANADA — SPERRY GYROSCOPE OTTAWA LTD., OTTAWA, ONTARIO

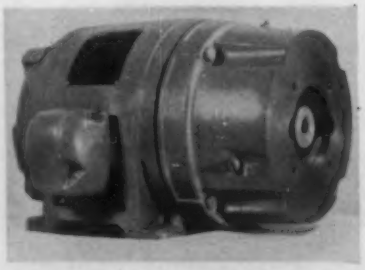
of 13 sizes available from manufacturer, in white, black or gray. **Panduit Corp, Dept PE, 14461 Waverly Ave, Midlothian, Ill.** See Booth 409 or
Circle 331 on Reader Service Card

Shell mold castings . . .

produced on automatic, two-state equipment capable of high production rates, offer surface tolerances held to ±0.015 in. Surface finish of castings is reported to reduce casting weight and often eliminate machining operations. **Ampco Metal Inc, 1745 S 38th St, Milwaukee 46.**
See Booth 1612 or
Circle 332 on Reader Service Card

Extruded rectangles . . .

in two grades of wear-resistant metal are available from stock in 55 sizes. Typical physical properties include 34,500- to 50,000-psi elastic limit of compression, and 210 to 310 Brinell hardness. For use as wear strips, wear plates, gibs, slides and ways. **Ampco Metal Inc, 1745 S 38th St, Milwaukee 46.** See Booth 1612 or
Circle 333 on Reader Service Card



Close-coupled pump motor . . .

is heavy-duty unit with corrosion-resistant, cast iron frame. Mounting bracket eliminates mounting base, adaptors; reduces over-all length of pump-motor package. Concentric mounting is possible through use of castings said to prevent warping of precision machined parts. Splined coupling allows direct pump connection. Single- and double-end models are available to fit all standard hydraulic pumps. Ratings range from ¾ to 50 hp. **US Electrical Motors Inc, Box 2058 Terminal Annex, Los Angeles 54.** See Booths 1704, 1706 or
Circle 334 on Reader Service Card

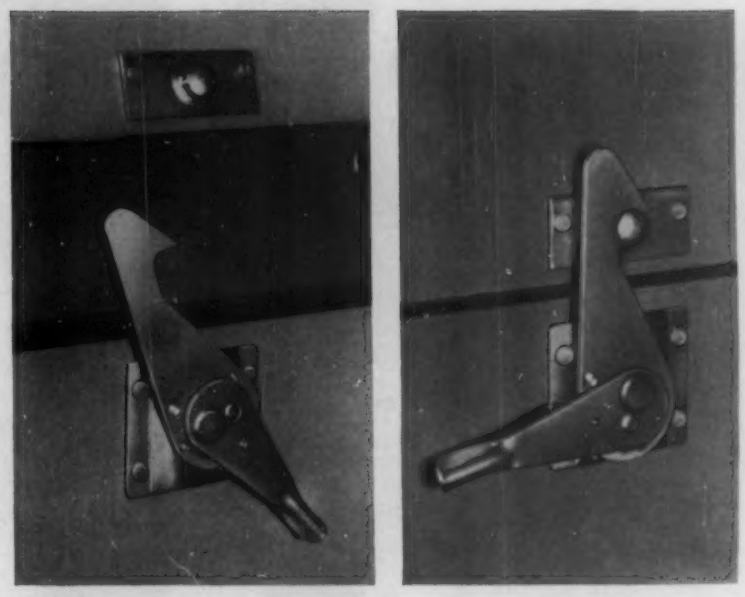
Motorized planetary reducer . . .

accepts any standard C-flange motor. Flexible coupling connects motor to input shaft of reducer. Ratio range is from 1.1:1 to

continued on page 208

WHAT HOOK-LOCK IS

HOOK-LOCK is a springless, positive-locking latching device which is ideally suited for use on rigidly specified military transit cases as well as less expensive commercial containers. It provides high closing pressure and tremendous load-carrying capacity...is impact and shock-proof. HOOK-LOCK is so designed that it lies flat against the mounting surface whether in open or closed position. Since operation is parallel to mounting surface, no space for operating clearance is required.

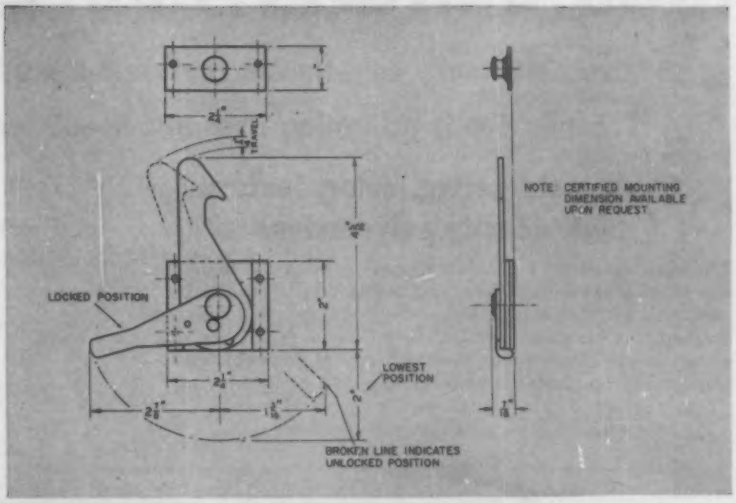


HOOK-LOCK lies flat against mounting surface, open or closed.

New—HOOK-LOCK container latch...It's flat!

FEATURES

- Shock-proof—solid construction...withstands high impact blows *directly on the fastener.*
- Closing pressure of 200 lb. Where needed, pull-down pressure can be substantially increased by modification of operating lever.
- Tensile load capacity: 750 lb.
- Compact—lies flat open or closed. Extends just 7/16" from container surface at thickest point.
- Positive-locking and springless. Unaffected by arctic temperatures.
- No operating clearance required, because hook and lever move parallel to mounting surface.


LOCKED POSITION
LOWEST POSITION
BROKEN LINE INDICATES UNLOCKED POSITION
NOTE: CERTIFIED MOUNTING DIMENSION AVAILABLE UPON REQUEST

IF YOU have questions regarding the possible application of HOOK-LOCK or other Simmons industrial fasteners to your particular needs, your inquiry will receive our immediate attention. Contact your nearest Simmons office or write direct.

BE SURE TO VISIT BOOTH 2434—1960 Design Engineering Show

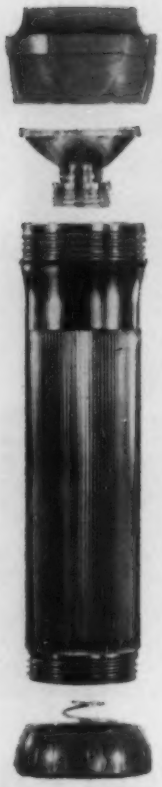
SIMMONS
FASTENER CORPORATION

1751 North Broadway, Albany 1, New York

See our 8-page catalog in Sweet's Product Design File

All-plastic case shows finely-drawn functional detail

Tube, lens ring, and cap are all molded of BAKELITE Brand high-density polyethylene. The designer made good use of this material's functional properties. Fine details are reproduced with extreme fidelity—serrations on the tube are precisely formed and provide a firm grip. Minimum finishing after molding helps keep mass production costs low. Tough and rigid with excellent chemical resistance, the flashlight will take hard industrial usage. Its gloss adds sales appeal. On top of all these design advantages, the low price of this material makes it an even stronger value.



Molded-in threads, hidden parting lines make this design unusual

NOTE: EXTERIOR SURFACE OF TUBE TO BE FREE OF ALL PARTING LINES

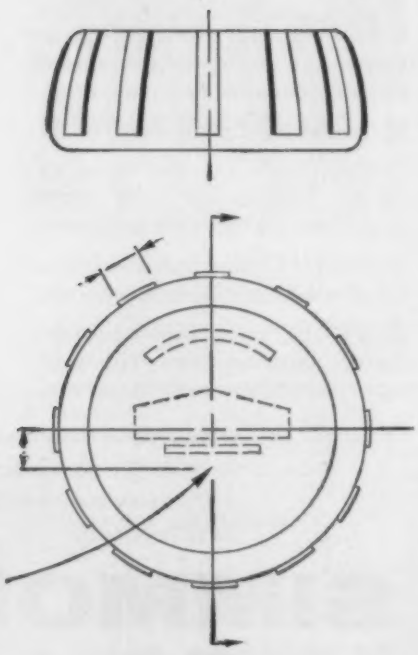
Because of the high temperature resistance of BAKELITE Brand high-density polyethylene, these flashlight components always hold their shape. The molded threads don't soften, keeping the lens ring and cap firmly in place. These are ten-pitch threads, easy to work, hard to strip.

While the threaded sections at the bottom and top of the tube required a parting line, the designer specified that the main body of the tube have no parting line. The one-piece mold used for this feature costs more, but the appearance of the finished product makes it worthwhile. A slight taper in the tube permits easy removal from the mold. Since holes for the switch plate are molded in, there's no need for subsequent operations such as drilling or piercing.

HIGH-DENSITY POLYETHYLENE ...

Clean mold gating, color, feature high-density polyethylene

The designer called for a conventional gate on the flashlight cap mold; the tube and lens ring molds have a "diaphragm" gate used in fabricating tubular plastic designs. See how the finished part compares with his design. The cap and lens ring come in three glossy colors—red, yellow, and green—an attractive combination with the black tube.



This was an informal test—

...but it demonstrated the toughness and impact resistance of the BAKELITE Brand high-density polyethylene used in the EVEREADY "Shop Lite." It came through the bump, bounce, and batter undamaged.

IDEA-MATERIAL for NEW DESIGNS

The EVEREADY "Shop Lite" gained several advantages when the designer chose this new polyethylene. Check the high points on these pages...

A new material often expands the designer's opportunities to try new ideas. This is especially true of high-density polyethylene, which offers properties that can reduce costs, extend performance, and improve appearance. Polyethylenes are only one group of BAKELITE Brand plastics—the others are epoxies, phenolics, styrenes, and vinyls—that you can draw on. Molded, laminated, extruded, or in coatings, BAKELITE Brand plastics can be a source of genuine product improvement.

Check their properties in Sweet's Product Design File, section 2a/ui

Visit our booth at the Design Engineering Show, New York Coliseum, May 23-26.

UNION CARBIDE

"Bakelite," "Eveready" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

Dept. AQ-113, Union Carbide Plastics Company
Division of Union Carbide Corporation
30 East 42nd Street, New York 17, N. Y.

Please send me information on the use of BAKELITE Brand Plastics in design with particular emphasis on these properties _____

The type of application being considered is _____

NAME _____

FIRM NAME _____

STREET _____

CITY _____ ZONE _____ STATE _____

CIRCLE 207 ON READER SERVICE CARD 207

50,000:1. Capacity ranges from 0.12 to 81.5 hp Output torque ranges from 50 to 113,000 in.-lb. **Winsmith Inc, Springville, Erie County, NY.** See Booth 528 or
Circle 335 on Reader Service Card

Cage-type roller bearings . . . for applications requiring max radial capacity have relieved-end roller to minimize high-stress concentration and fatigue at corners. Rollers are square-end type and retained in pockets of tubular steel cages to maintain alignment while running. One series (at right in photo) is interchangeable dimensionally with standard needle bearings, but uses rollers of larger dia and length for increased load capacity. Second series (at left) is made in inch sizes dimensionally between standard needle bearings and conventional cylindrical roller bearings. This series is heavier-sectioned and provides higher load capacity than first series. **Orange Roller Bearing Co Inc, 557 Main St, Orange, NJ.**
See Booth 1636 or
Circle 336 on Reader Service Card

Two- and three-way valves . . . in five series have been introduced. Three-way valves for use with medium-size cylinders are available in orifice sizes of $\frac{3}{32}$, $\frac{1}{8}$ and $\frac{5}{32}$ in. Max operating pressure differentials up to 250 psi are possible.

Two-way valves with $\frac{3}{4}$- and 1-in. dia orifices are designed to control such common media as air, oil and water. Max operating pressure differential is from 5 to 150 psi. Diaphragm of laminates of nylon and Buna-N rubber is fully supported in off and on position. Three-way, high-flow solenoid valves are suitable for general industrial use. Mount in any position directly in line and operate on pressure differential of 5 to 150 psi. Valves are currently offered in $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{3}{4}$-in. full effective orifice sizes.

Two-way solenoid valves now include high-pressure models in two-way, normally closed construction and wide range of voltages and frequencies. Orifice size is $\frac{1}{4}$ in. dia, with $\frac{1}{4}$-in. NPTF ports. Operating pressure differentials are 5 to 1250 psi on ac service; 5 to 1000 psi on dc service.

Two- and three-way valves handle liq

continued on page 210

See it . . . get a free sample . . . test it yourself at Booth No. 227 Design Engineering Show.

This remarkable new drafting film on "Cronar"* withstands all kinds of punishment and *lasts indefinitely!* Ideal for all types of drawings — pencil or ink. Costs no more than cloths or vellums! Matte finish on one or both sides — no extra cost.

Tomorrow's drafting film Today • Reduces Smudging • Heat Resistant • Resists Cracking • Superior Transparency • High Tear Strength • Erases Easily • Moisture Proof • Very Flexible • No Stretch or Shrink • Lies Flat • Won't Yellow with Age • Doesn't "Dog-ear".

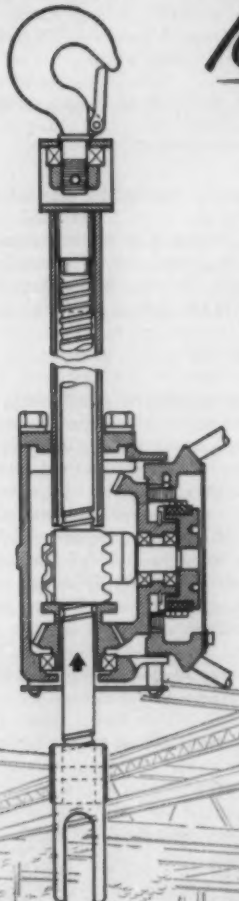
*A registered DuPont trademark

CHART-PAK, INC.

ORIGINATOR OF THE TAPE METHOD OF DRAFTING

175 River Road, Leeds, Mass.

NEW Whiting Ladle Handler Lifts 100 lbs for Every Pound of Effort!

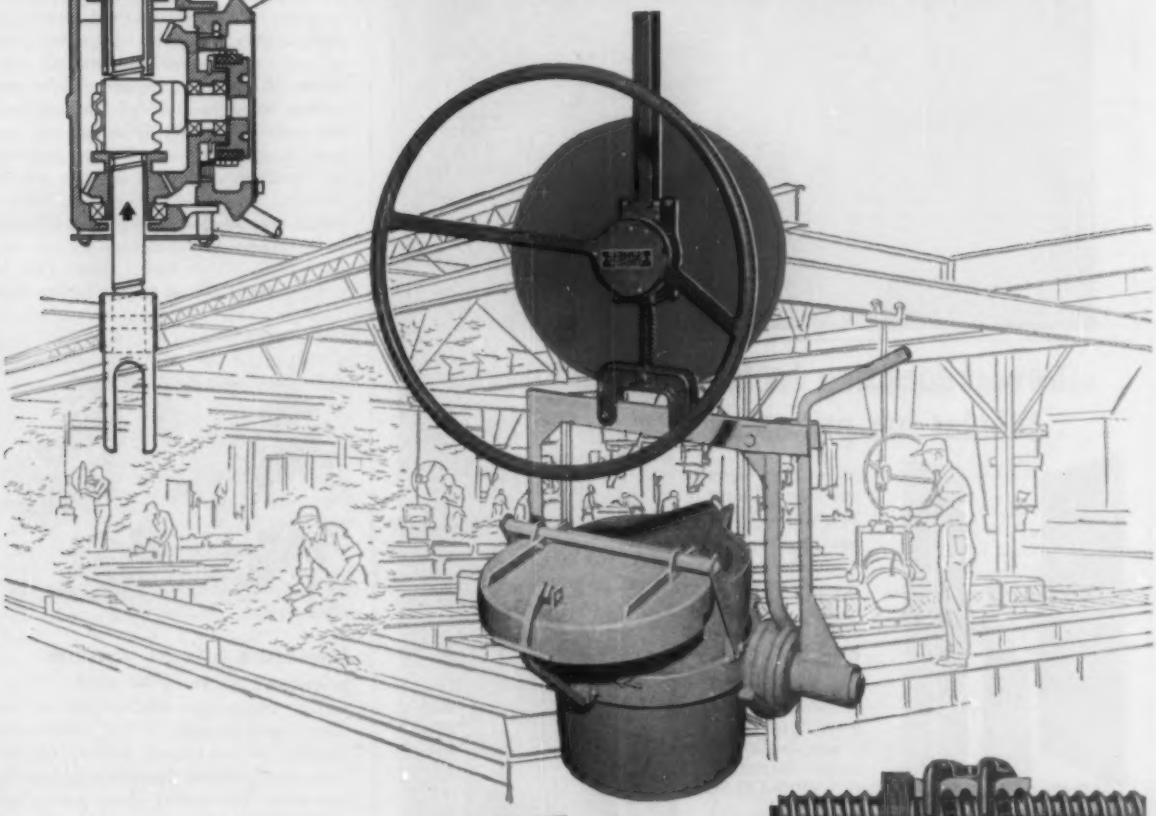


. . . made possible by the Saginaw b/b Screw!

The Whiting Corporation, heavy foundry equipment manufacturers, designed a ladle handler that lets the operator manually raise and lower a gross weight of over 2250 pounds with maximum ease and control. The Saginaw Ball Bearing Screw got the actuation job!

A turn of the handwheel on the new 'H-E' Ladle Handler transmits torque to the Saginaw Screw which converts *rotary* motion into *linear* motion with over *90% efficiency*. This, with a unique clutch-brake spring, helps the operator LIFT 100 POUNDS FOR EVERY POUND OF EFFORT, and maintain control at all times! The Saginaw Screw also provided savings in maintenance, wear, parts and weight.

The Saginaw Screw may be able to improve your product's performance and increase its sales acceptance. Write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*



Actuation To Fit Your Individual Requirements

Have been built as small as 3/16 in. B.C.D. and 3/4 in. long, as large as 6 in. B.C.D. and 40 ft. long. Larger sizes can be built to your order.

Saginaw ball bearing Screw

WORLD'S MOST EFFICIENT ACTUATION DEVICE

uids or gases for control and instrumentation, with 400-psi max operating pressure differential. Orifices are $\frac{1}{32}$ in.; ports are $\frac{1}{8}$ or $\frac{1}{4}$ in. NPT. **Skinner Electric Valve Div, Skinner Chuck Co, 95 Edgewood Ave, New Britain, Conn.**

See Booth 1813 or
Circle 337 on Reader Service Card

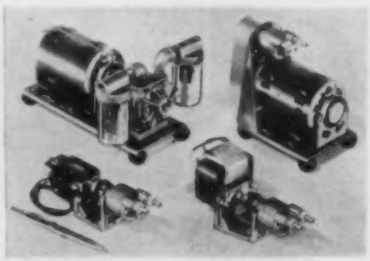
Infinitely variable speed drive

offers ratings up to 50 hp. Also available are motorized units with automatic controls. **Link-Belt Co, Prudential Plaza, Chicago 1.** See Booths 2105-2107 or
Circle 338 on Reader Service Card

Flame-resistant materials . . .

to be offered include three new grades of laminated plastic and a moisture-resistant, vulcanized fiber. A material combining cold-punching properties with flame resistance, a flame-resistant material, and a low-cost mechanical grade will be presented. Moisture-resistant vulcanized fiber, also available, is said to be low-cost material developed to meet UL requirements for insulation of current-carrying parts in electrical equipment. **National Vulcanized Fibre Co, Maryland Ave and Beech St, Wilmington 99, Del.**

See Booth 1913 or
Circle 339 on Reader Service Card



Miniature oil-less vacuum pumps

and air compressors are available in two basic types in total of five rotary vane models. All run entirely without oil; carbon vanes lubricate themselves. Air pump has rotor dia smaller than penny and weighs 11 oz, less motor. Offered with series-wound motor that delivers up to 0.67 cfm running open, and up to 20 in. Hg vacuum or 10 psig; split-phase motor with belt drive and piggy-back pump mounting that delivers 0.48 cfm and up to 20 in. vacuum or 15 psig; and shaded-pole motor that produces 0.35 cfm or vacuum up to 20 in. and pressure up to 10 psig. Model 0630 is for direct drive

continued on page 211

POLYPENCO® MC NYLON

an economic breakthrough in nylon production

New processing techniques drop nylon tubular bar prices as much as 50%

ROD AND SLAB

Rod up to 17" in diameter, and slab from 1 to 5 inches thick in sections of 2 ft. x 3 ft. are available on special request. Other symmetrical shapes—produced with new economy—and in larger sizes than heretofore produced—are under development.

New design opportunities are open to manufacturers and users of large bronze and babbit bearings.

POLYPENCO MC Nylon 901, a specially formulated bearing compound, is available in tubular bars at prices below those of quality bronze bushings.

Polymer's new MC Nylon has improved wear characteristics and greater resistance to deformation under load . . . proven by field tests.

TUBULAR BAR STOCK SIZES

MC Nylon tubular bars, the first standard availability in MC Nylon, are made in outside diameters ranging from 2" to 15". Wall thicknesses of ⅜", ½", ¾" and 1" are standard with wall thicknesses up to 2" made to order. Standard lengths up to 13'. Supplied in POLYPENCO blue.

Call or write today for full information.

See MC Nylon in Polymer Booth #1513 Design Engineering Show May 23-26 Coliseum, New York City

POLYPENCO®

The Polymer Corporation of Penna.
Reading, Pa.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

through motor coupling and delivers up to 0.6 cfm, to 24 in. vacuum or 25 psig. Choice of 1/20- or 1/12-hp split-phase motors are available. Model 1030 has identical exterior, but larger capacity up to 1 cfm, up to 25 in. vacuum or 15 psig. To be priced under $50. From stock. **Gast Mfg Corp, P O Box 117, Benton Harbor, Mich.** See Booth 925 or
Circle 340 on Reader Service Card

Vacuum-pressure pumps . . .

are now offered in two new models. Integral vacuum-pressure pump and motor has pump capacity of 2.4 cfm with vacuum of 27 in. Hg or pressure to 20 psig. Motor is ½-hp unit. Entire unit measures 15 x 11 x 7½ in. high. Second model is oil-less double-cylinder pump. One cylinder produces vacuums to 25 in. Hg; the other cylinder produces pressures to 15 psig. Pump is oil-less type and equipped with presealed, antifriction bearings. Available in three sizes ranging from 8 to 14 cfm. **Leiman Bros Inc, 166 Christie St, Newark 5, N J.** See Booth 1630 or
Circle 341 on Reader Service Card

Motorized speed-reducer line

has been expanded to include units for ⅛- to ½-hp motor range in-line drives. Larger, helical-geared, motorized speed reducers provide ratings for drives up to 10 hp. **Boston Gear Works, 67 Hayward St, Quincy 71, Mass.** See Booth 1808 or
Circle 342 on Reader Service Card

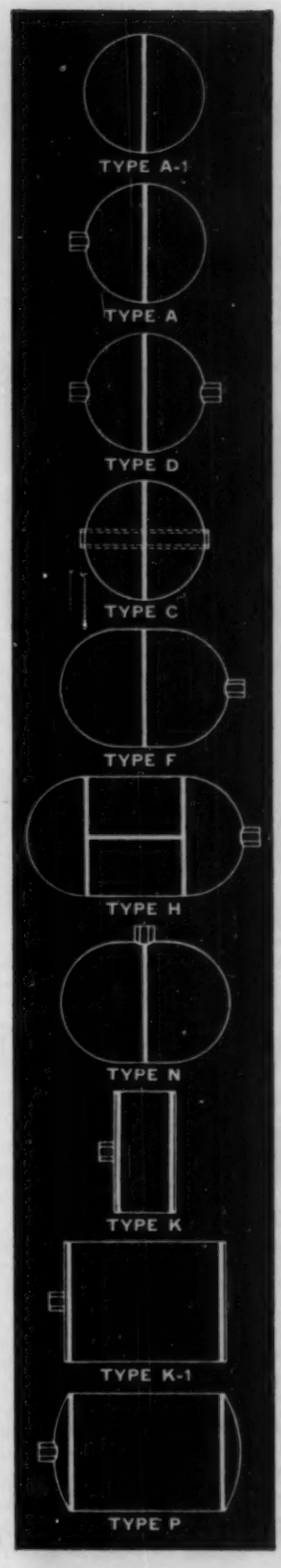
Printing is sandwiched . . .

between surface film of Mylar and backing layer of aluminum or vinyl for such applications as nameplates and labels. This produces identifying product with resistance to abrasion, weathering and other forms of surface attack. **Avery Label Co, 2123 E 9th St, Cleveland 15.**
See Booth 535 or
Circle 343 on Reader Service Card

Pure beryllium tubing . . .

in representative sizes from 0.250 to 2 in. OD, is produced by Chesterfield Tube Co, Sub Tube Investments Ltd, London, England. Superior Tube has been appointed as sales agent in the US. No health hazards are reported to exist if well-defined precautions are taken in handling beryllium. **Superior Tube Co, P O Box 191, Norristown, Penna.**
See Booth 2020 or
Circle 344 on Reader Service Card

continued on page 212



Floats!

all shapes and sizes for high pressure service

For buoyancy mediums, fluid chambers or pressure vessels, Nicholson precision welded floats come *exactly* as you want them . . . spherical, elliptical, cylindrical . . . 2″ to 14″ in diameter . . . and, for working pressures up to 2500 lbs. Float halves are die formed with inward rolled edges, not spun laminated or electrodeposited. *Steel floats* . . . with chromium, cadmium or copper plating . . . with sandblast or pickled finish; *Stainless Steel* and *Monel floats* . . . rough buffed, polished or with smoothly-ground, highly finished welds. Exceptional resistance to pressure and corrosion. Use coupon for more details.

Tell us how you want yours

Material_____
Shape_____
Size_____
Pressure_____
NAME_____
TITLE_____
COMPANY_____
STREET_____
CITY_____ STATE_____

W. H. NICHOLSON and COMPANY
12 Oregon St.
Wilkes-Barre, Pa.

NICHOLSON
of Wilkes-Barre

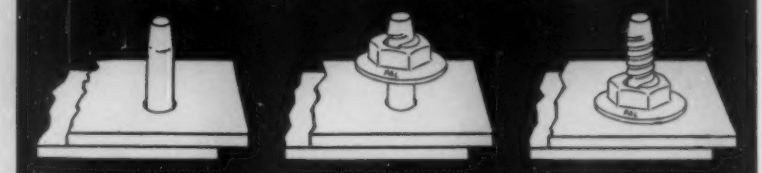
Save Threading Costs!

GET YOUR THREADS *FREE*

by fastening with

PALNUT® SELF-THREADING NUTS

Automatically form deep, clean threads while turning on unthreaded studs, rods, wire and pins



- **Low in price**
- **Easy, fast assembly**
- **Strong, vibration-proof grip**

Spring-tempered steel PALNUT Self-threading Nuts apply like any ordinary nut, using standard tools or PALNUT high-speed magnetized wrenches. Always assemble perfectly—even on off-angle studs, in confined space, against curved surfaces. Provide vibration-proof grip, seated or unseated. May be removed and re-used on same stud. Use them on zinc die cast studs, plated or unplated; also steel, brass, aluminum, high-impact plastic or any malleable material.

WASHER TYPE—STYLE SD

One-piece self-threading nut performs functions of ordinary nut, lockwasher and flat washer. Resilient washer base avoids distortion of sheet metal or damage to fragile parts. Several base diameters; also with bonded-in plastisol compound to seal out water and dirt. Sizes for ⅛", 5/32", 3/16" and ¼" dia. studs and rod.

REGULAR TYPE—STYLE SR

For assemblies where space is limited. Uses shorter studs, less seating area. Competitive with push-on fasteners, assembles fast, assures tight assemblies. May be used with internal wrench. Sizes for ⅛", 5/32" and 3/16" dia. rod, in various hex widths.

ACORN TYPE—STYLE SC

Decorative, dome-shaped self-threading nut covers end of studs or rods to protect against scratching, snagging or tearing, while adding a pleasing appearance. Costs less than threaded cap nuts. Sizes for ⅛", 5/32" and 3/16" dia. studs and rods.

Write for Bulletin 585-A and Free Samples, stating style, size and application.

PALNUT®

THE PALNUT COMPANY

Division of United-Carr Fastener Corp.

65 Glen Road, Mountainside, N. J.

Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LOCK NUTS and FASTENERS

Portable time switch . . .

for electrically operated devices has outlet incorporated in unit. Rated 10 amp, 125 v ac; 30- and 60-min. timing cycles are available. Reported to be UL- and CSA-inspected. **M H Rhodes Inc, 30 Bartholomew Ave, Hartford 6, Conn.**

See Booth 2231 or

Circle 345 on Reader Service Card

Stressproof steel bars . . .

will be offered in rounds up to 4 in. dia in five new sizes: 3½, 3⅝, 3¾, 3⅞, and 4 in. These sizes will be provided with 100,000 psi yield strength and machinability of 83% of B1112, which are the same as for smaller diameters. **La Salle Steel Co, 1420 150th St, Hammond, Ind.**

See Booth 1321 or

Circle 346 on Reader Service Card

Dual-wheel caster . . .

is self-aligning unit for heavy-duty transporting dollies. Equipped with two 10x4-in. press-on tires with vulcanized rubber tread, roller bearings and four-position lock. Has load rating of 2500 lb at 10 mph. **Faultless Caster Corp, Dept PR-188, Evansville 7, Ind. See Booth 2202 or**

Circle 347 on Reader Service Card

Lightweight stainless tubing . . .

for expansion problems handles axial, radial, dual radial and shear movement while conveying large volumes of liquids or gases. Working pressure is rated from 50 psi max to 275 psi max in sizes from 5 through 14 in. ID. End fittings can either be welding nipples, fixed flanges or floating flanges. **Anaconda Metal Hose Div, American Brass Co, P O Box 791, Waterbury 20, Conn.** **See Booth 1236 or**

Circle 348 on Reader Service Card

Nylon snap bushings . . .

are now available for mounting hole diameters of ⅛ up to 1¾ in. Carry both UL and CSA approval. **Heyman Mfg Co, Kenilworth, NJ.** **See Booth 1217 or**

Circle 349 on Reader Service Card

Plastic-tipped needle valves . . .

for service up to 3000 psi are said to prevent galling and scoring at seat because of excessive tightening. Plastic stem point provides leaktight shutoff. Made of nylon or Kel-F, tips are reported to withstand twice the normal closing force through

continued on page 216

"ALCOA ALUMINUM OFFERS A CHOICE OF TWO SCREW MACHINE STOCK ALLOYS FOR STRENGTH: 2017 AND 2024!"

Precision-made, high-volume screw machine parts cost less in aluminum

Here are the strongest of all Alcoa® Aluminum screw machine alloys. Both will give you superb machinability. Both will give a fine, clean finish. Alcoa Alloy 2017-T4 or -T451 is exceptionally good for deep drilling operations. Alloy 2024-T4 or -T351 offers high shear strength . . . which makes it a popular choice for fasteners and fittings. These alloys will give three times as many parts per pound as other, heavier metals, raise your profits by cutting your over-all unit costs.

Ask your Alcoa distributor or Alcoa sales office for your free *Alcoa Conversion Calculator* . . . which makes cost conversions from brass to aluminum and computes costs quickly . . . and your free *Alcoa Screw Machine Stock Estimating and Operating Data Book*, a comprehensive, easy-to-use book of technical data on aluminum screw machine stock. Get full information on other Alcoa alloys: 2011-T3 or -T8 for faster cutting, 6061-T6 or -T651 for superior finishes, excellent joining characteristics and extra corrosion resistance. Aluminum Company of America, 841-E Alcoa Building, Pittsburgh 19, Pennsylvania.

GET ALL THESE BONUSES WITH EVERY ALCOA ALLOY:

1. Wide range of stock sizes for important price advantages.
2. Guaranteed market for up to 60 per cent of your Alcoa Aluminum turnings and borings.
3. Extensive mill and distributor inventory to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).

See us at the Design Show—Booth 2032

ALCOA ALUMINUM

SCREW MACHINE STOCK

CIRCLE 213 ON READER SERVICE CARD 213

in only 90 days...

101 aluminum fabricators have ...Amchem's newest

ALODINE 1200S protects aluminum best ...at less cost, in less time!

To the hundreds of long-time users of Amchem Alodine—the first, low cost effective surface conversion treatment for aluminum—add a new host of fabricators who are employing the newest Alodine development—ALODINE 1200S!

If you are producing aluminum—any type of aluminum—you'll want to investigate the production advantages and profit potentialities of this new Alodine pre-paint process that provides constant, uniform quality as well as big savings in time, equipment and processing costs!

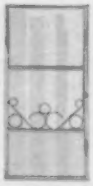
Through increased chemical activity ALODINE 1200S slashes processing time *up to 50 percent!* A 1200S system can be installed on your production line quickly and conveniently . . . and bath is maintained chemically . . . no special equipment required to control contamination! In an ALODINE 1200S system, products can be processed through continuous dip in the same time cycle other conversion coatings require for continuous spray lines! That means lower initial equipment and maintenance costs, wider range of product applications regardless of the application method—brush, dip, continuous strip or spray. ALODINE 1200S is qualified under Government Specification MIL-C-5541.

ALODINE 1200S is Amchem's positive answer to constant uniform quality in aluminum processing. Put its assured protection and production flexibility to work for your aluminum products and market them with greater confidence!

switched to Alodine 1200S conversion coating!

FASTER, LOW COST, EFFECTIVE AND FLEXIBLE, ALODINE 1200S IS PROVIDING NEW HIGHS

aluminum stop signs

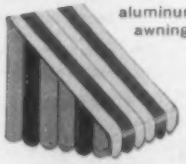

aluminum doors

aluminum venetian blinds

IN CORROSION RESISTANCE AND PAINT BONDING QUALITIES TO THESE AND

aluminum cameras

aluminum house trailers


aluminum awnings

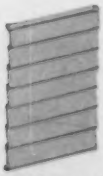
MANY MORE FINE PRODUCTS IN THE ALUMINUM INDUSTRY. YOU, TOO, CAN

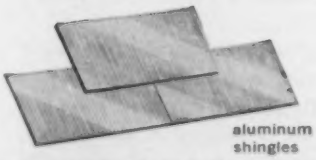
aluminum boats

aluminum license plates

aluminum missile parts

UPGRADE YOUR PRODUCTS' CONSUMER APPEAL WITH ALODINE PROTECTION.


aluminum siding


aluminum shingles

aluminum mail boxes

CONTACT YOUR NEAREST AMCHEM REPRESENTATIVE FOR COMPLETE DETAILS!

AMCHEM

ALODINE 1200S

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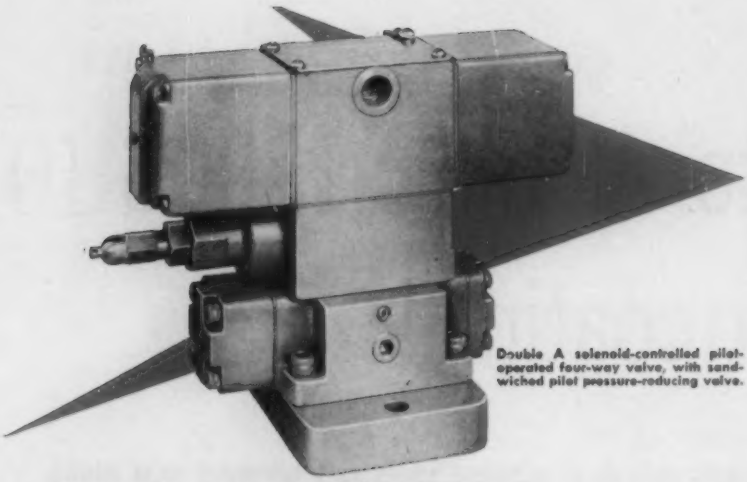
(Formerly American Chemical Paint Co.)

AMBLER, PA. • Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.



Double A solenoid-controlled pilot-operated four-way valve, with sandwiched pilot pressure-reducing valve.

From Brown & Sharpe–

These Big Double A Valve Features

Get *all* the features *you want* in the valves you buy. Get JIC standards *plus* these extra features and choices by buying Double A solenoid-controlled, pilot-operated directional valves:

- Choose from four different solenoids: AC, DC, AC oil-immersed, and DC with palm-button.
- Solenoids have rubber shock absorbers and exclusive separate drain for more reliable, faster action.
- Just one solenoid and pilot valve combination will serve four valve bodies with pipe connections from $\frac{3}{8}$" through 2", and three pressure capacities (2,000, 3,000, and 5,000 psi).
- New optional CircuitStak pilot pressure-reducing valve sandwiches between main body and pilot valve to make possible higher pressure operation of the main valve body.
- New optional CircuitStak pilot flow-amplifying valve requires no piping, provides faster spool shifting of larger valve sizes.
- Fifteen different standard cataloged main valve spool types are available, to accurately match your demands.
- Two kinds of sub-plates, the usual back-entering plus the back-and-side entering type, are offered.
- SAE straight thread openings are optional at no extra cost.

See for yourself how much more Double A valves offer, from the sensible flow ratings (based on *minimum* pressure drops) right down to the extra mounting bolts (to prevent O-ring troubles under high pressures). Contact your nearest Double A hydraulic distributor. Or write to **Double A Products Co.**, a subsidiary of Brown & Sharpe Mfg. Co., Manchester, Michigan.

Brown & Sharpe
HYDRAULICS DIVISION

GEAR, VANE & CENTRIFUGAL PUMPS
DOUBLE A VALVES
GEROTOR PUMPS
POWER UNITS

PROGRESS IN PRECISION FOR OVER 125 YEARS

COMPLETE INFORMATION on Double A solenoid-controlled sub-plate mounted four-way valves.
ASK FOR Series 9000 Engineering Data Sheets.

700 cycles of operation at 3500 psi. Available in $\frac{1}{8}$- and $\frac{1}{4}$-in. pipe sizes and $\frac{1}{4}$-in. tube size. **Hoke Inc, 1 Tenakill Park, Cresskill, NJ.** See Booth 1536 or
Circle 350 on Reader Service Card

Worm-gear speed reducers . . .

are fan-cooled units available in 25 types and over 135 sizes. Ratios range from 5:1 to 3600:1, with torque ratings up to 135,000 in.-lb and horsepower ratings up to 150. Right-angle drives can operate at high input speeds and cover range from fhp to large horsepower motors. **Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.** See booth 2105 or
Circle 351 on Reader Service Card

Actuating controls . . .

for operating small engines, air-conditioning units, valves and similar equipment mount on shaft, bulkhead or channel. Typical controls include dual control with push-button setting line and rack-and-gear to determine setting on twin line; dual control with twin levers for push-pull control; single-actuating-lever control. **Weatherhead Co, 128 W Washington Blvd, Ft Wayne, Ind.**
See Booth 1601 or
Circle 352 on Reader Service Card

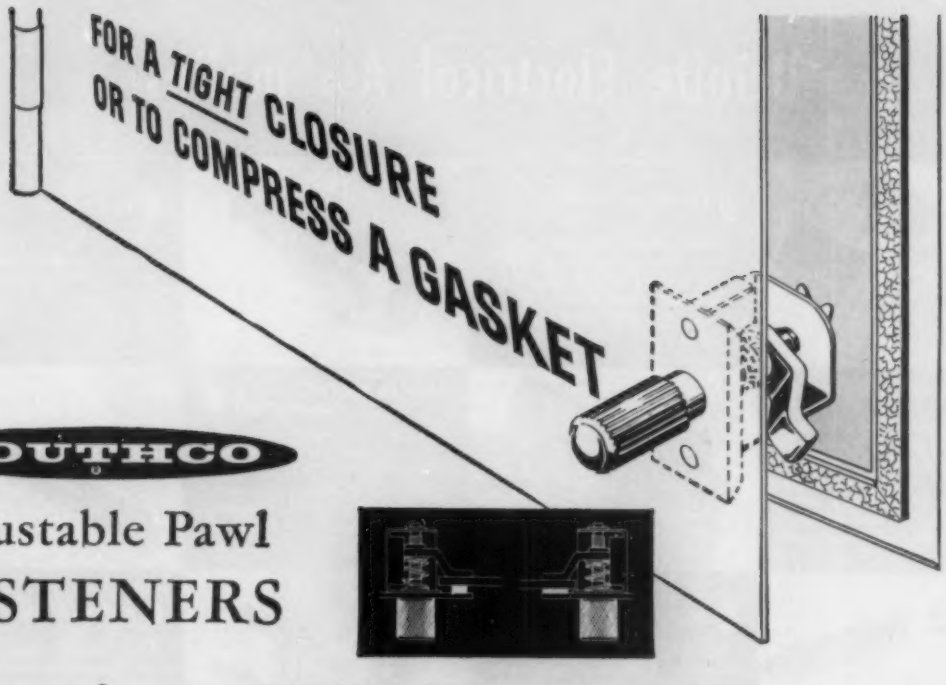
Miniature molded screws . . .

can now be ordered from stock in three new thread sizes: 0-80, 1-72 and 4-90. Nylon fasteners are available in complete range of lengths and head types. New sizes are offered in $\frac{3}{8}$-, $\frac{1}{2}$- and $\frac{3}{4}$-in. lengths, respectively. **Gries Reproducer Corp, 125 Beechwood Ave, New Rochelle, NY.**
See Booth 2435 or
Circle 353 on Reader Service Card

Four-post drafting table . . .

has drawing board equipped with channeled steel cleats on both ends to retain accuracy, and is surfaced with linoleum. Catalog, tool and reference drawer—standard equipment—is steel with matching wood front. Handwheels control hidden tilting-rod for board adjustments from 0

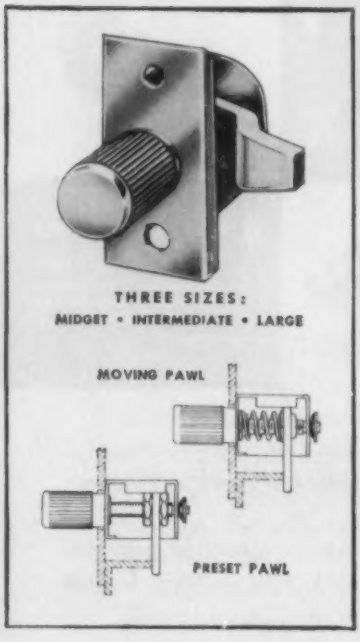
continued on page 220



SOUTHCO

Adjustable Pawl FASTENERS

¼ turn closes—additional turning tightens



Just slip the knob through a hole in the door (any door thickness—it doesn't matter). Fasten with two rivets, bolts, or welds. The Southco Adjustable Pawl Fastener will fit your door frame, even when material gauge varies between units.

Turn the knob. The first quarter turn latches the door. Now keep turning. You're pulling the door tightly against its frame. You can compress a gasket, form a dust or moisture seal, overcome vibration.

You'll save installation time and satisfy your customers with these rugged, attractive, pre-assembled fasteners. Ideal for heavy machines, electronic consoles, miniaturized units, cabinets, missiles, slide-mounted modules, etc.

FREE!
FASTENER HANDBOOK
Send for your free copy of Southco Fastener Handbook. Gives engineering data on many fasteners. Write to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

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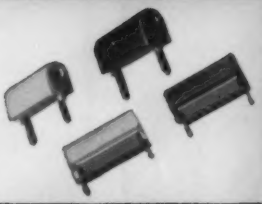
SOUTHCO FASTENERS

LION

CIRCLE 217 ON READER SERVICE CARD

Ucinite Electrical Assemblies



PRINTED CIRCUIT TEST JACKS

For permanent assembly to ptd. circuit bds. Accessible to std. .080 probes without adaptors. Gold-over-silver berylco contacts . . . color coded nylon bodies.

TEST JACKS

Ucinite's quality jack for .080 probes. Beryllium copper contacts. Nylon insulation in colors. Metal shell for firm, dependable mounting. MS16108 types available.

STAMPED CIRCUITS

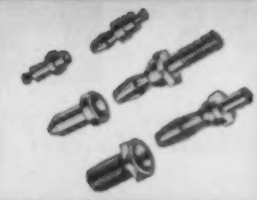
"Printed circuitry" by a stamping process free of electrolytic contamination. Injection and thermoset molded housings simplify miniaturization of intricate packages and permit complete flexibility of basic raw materials.

PRINTED CIRCUIT CONNECTORS

Unique torsion-bar contacts, provide consistent performance unaffected by repeated insertions of maximum and minimum tolerance boards. Available in various multiples of contacts.

NEON INDICATOR LIGHTS

Smallest, complete, low-cost, snap-in assemblies available . . . lenses can be molded with facets, lettering, trademarks, etc., in glass or plastic of any color.

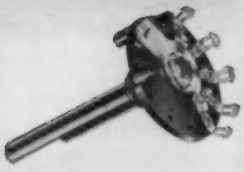


BANANA PINS

Four sizes of plugs with one-piece beryllium-copper springs. Adaptable mounting ends in threaded, staking or solder lug types. Mating jacks also available.

"PK" MOLDED SWITCH

Single wafer rotary switches in rugged, molded construction. Economical, durable. Single pole, two or three position types available.



AIRCRAFT SNAP SWITCHES

Precision, momentary contact, push-button types made to MS25089. Small and dependable. Hermetically sealed and other special versions are available.

AIRCRAFT COMMUNICATION PLUGS AND JACKS

4-conductor type made to rigid Mil. Specs . . . U92A/U Jack . . . U93A/U Plug . . . U94A/U Switch-Jack combination.

VIBRATION ISOLATORS

Equiflex (1:1 ratio) metal mounts ensure long life, fit small spaces; can be used in any direction. A range of sizes, cup or plate mountings.

With years of specialized experience in the electronics field and complete facilities for the volume production of small metal stampings as well as the assembly of metal to plastic and ceramic components, Ucinite is fully equipped to supply you with special electrical parts and assemblies . . . designed, assembled, wired and marked to your specifications.

* * *

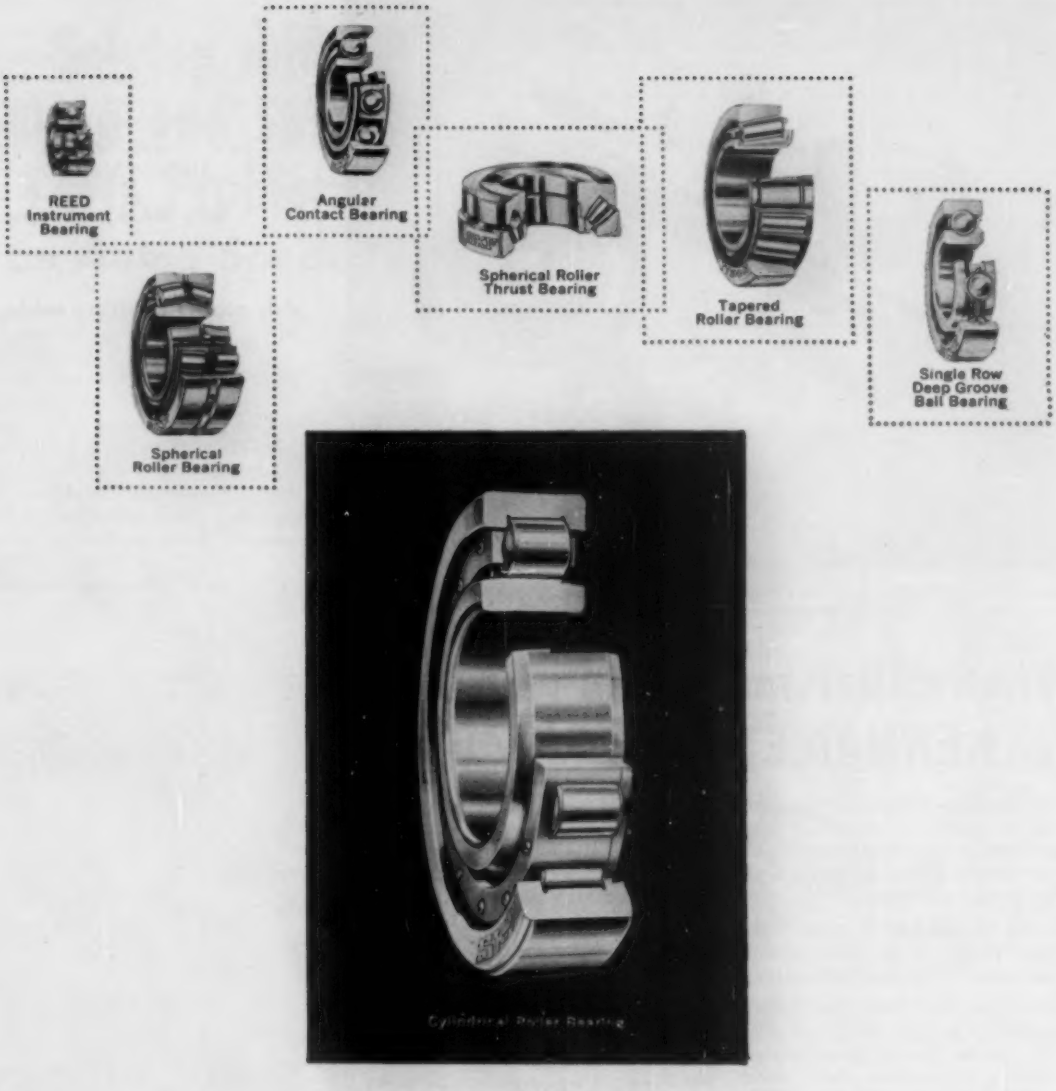
For complete design, engineering and production service, call your nearest Ucinite field engineer.

ELECTRICAL ★ DOT ★ ASSEMBLIES

Manufactured by

The UCINITE COMPANY

Division of United-Carr Fastener Corp., Newtonville 60, Mass.



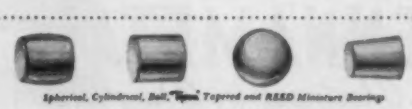
What's a "special size" in production bearings?

SKF makes so many standard sizes, there's practically no such thing as a "special size" of bearing. They range from tiny instrument bearings right up to four-row tapered roller bearings—and account for almost every possible bore size in-between.

Take SKF's standard cylindrical roller bearing, for example. It's promptly available in 154 sizes of single- and double-row types —for shaft diameters ranging from 1" to 9.5". Every size, in both types, offers high radial capacity in relation to its size and operates at highest speeds because of its very low friction.

So, before you specify a "special size" bearing, call the nearest SKF sales office first. The odds are better than 1,000 to 1 that there's already a standard SKF bearing of exactly the size you need. 6007

See them at the SKF Booth #1932 at the Design Engineering Show



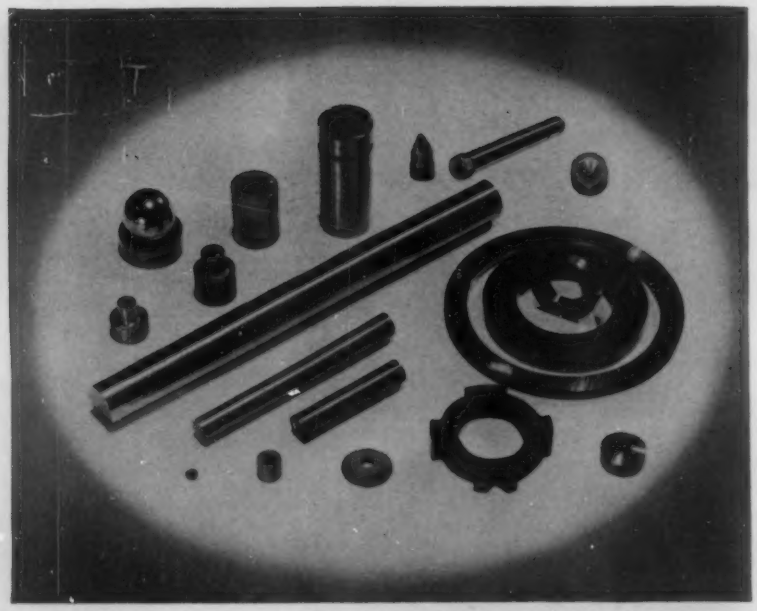
Spherical, Cylindrical, Ball, "Thrust," Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

SKF.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

CIRCLE 219 ON READER SERVICE CARD



Kennametal can be supplied as standard rectangular blanks, discs, rods, tubes, flats, balls, rings . . . and can be extruded, pressed, machined or ground . . . to precise tolerances for specific requirements.

When other materials won't do ...KENNAMETAL* usually will

High hardness and strength; resistance to abrasion, corrosion and high temperatures set Kennametal hard carbide alloys apart from all other design materials.

- Kennametal has an extremely high YME . . . up to 94 million psi compared to steel's 30 million.
- Some grades of Kennametal have a density as high as 15.5 gms/cc . . . twice that of heat treated steel . . . while other grades stand up for days in boiling 5% HNO_3 and 5% H_2SO_4.
- Kennametal is extremely hard . . . up to 94.7 Rockwell A.
- Kentanium,* a series of hard titanium carbide alloys, retains sufficient strength for many applications at temperatures as high as 2200°F.

Very broad applications have been found for these remarkable characteristics: long-wearing plungers, compressor cylinder liners, seal rings for rotary pumps, bushings, valve parts, high temperature sensor elements and hundreds of other critical component parts are being made from Kennametal.

Pushing design frontiers ahead means forcing back the barriers of wear, pressures and temperatures. For example, a pump manufacturer recently used Kennametal to obtain a large pumping capacity from a small pump. Using Kennametal for critical operating parts permitted faster speeds and higher pressures, without increasing pump size. A simple answer, but made possible only by the great wear- and corrosion-resistant characteristics of Kennametal.

Perhaps Kennametal can solve one of your problems. If you'd like more information, write for our Booklet B111A, Department MD, KENNAMETAL INC., Latrobe, Pa.

*Trademark 0-7291

See our display
BOOTH 1305
DESIGN ENGINEERING SHOW
New York Coliseum
May 23-26

INDUSTRY AND
KENNAMETAL
...Partners in Progress

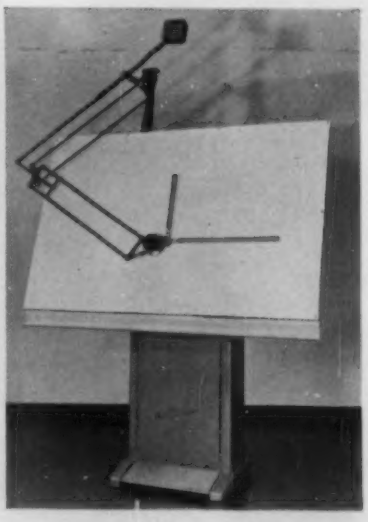
to 40%. Table is offered in four board sizes and two heights. The 31-in.-high table permits use of low posture-type chair. Canted leg styling utilizes only front and back crossrails, reducing structural members. **Hamilton Mfg Co, Two Rivers, Wis.**

See Booth 2230 or
Circle 354 on Reader Service Card

Adjustable drafting table . . .

has flat drawing surface that adjusts from desk height of 29 in. to drafting-table height of 38 in. Height and top-tilt adjustments are made from front of table and are counterbalanced. Top tilts from horizontal to 90° vertical. Table tops are available in 37½x54 and 37½x60-in. sizes. Tops are made of solid basswood with steel edges. **Mayline Co Inc, 619 N Commerce St, Sheboygan, Wis.**

See Booths 1615-1617 or
Circle 355 on Reader Service Card



Two new drafting machines . . .

include coordinate drawing machine with direct illumination and drafting unit with counterweights built into column of table. Drawing machine is said to be accurate to 0.0012 in. Plotting mechanisms for x- and y-directions glide on ballbearings. Equipped with interchangeable scales in any desired combination of ratios, in metric or English units. Interchangeable drafting accessories are available. Drafting unit (illustrated) has vertical movement that is effected in ballbearing roller guides free from play. Brake is actuated by pedal. Drawing board is tilted by means of lever. Available in four board sizes. **Unitech Corp, 50 Colfax Ave, Clifton, NJ.**

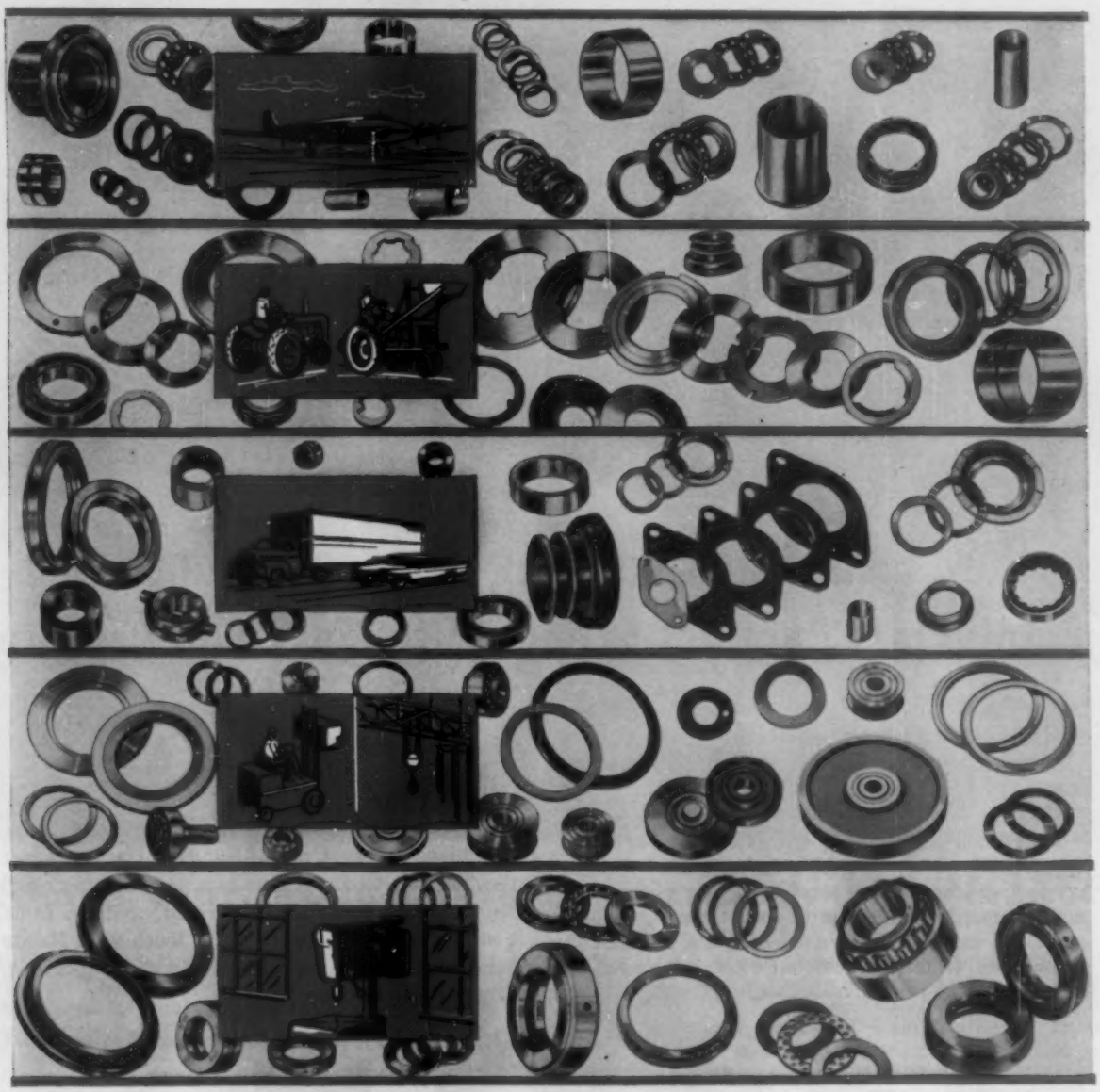
See Booth 416 or
Circle 356 on Reader Service Card

Solving difficult Bearing and Special Parts Problems–

an Aetna Specialty

The challenge of new and unusual problems is of continuous interest to Aetna design and application engineers. Their readiness to accept the difficult has established Aetna as a leading source for specially engineered or hard-to-make bearings, and hardened and ground precision parts.

Whatever your problems may be, the Aetna engineering facilities for design and application are available to assist you. Why not outline your anti-friction or parts problems for Aetna study, consideration, and recommendations on how to best achieve operational efficiency and long life expectancy in your products.



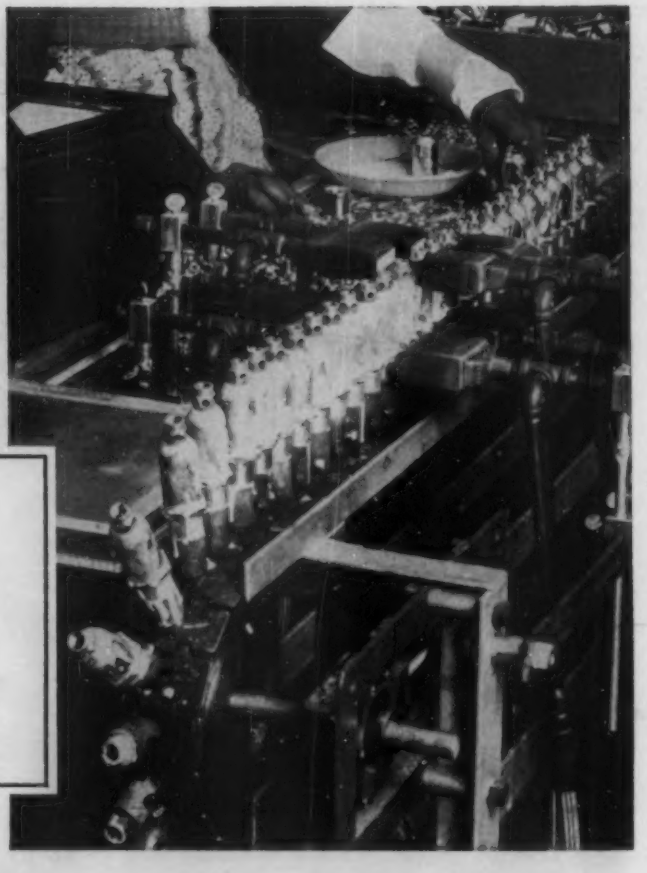
Aetna

AETNA BALL and ROLLER BEARING COMPANY
DIVISION OF PARKERSBURG-AETNA CORPORATION

4600 SCHUBERT AVE.
CHICAGO 39, ILL.

ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1918

CIRCLE 221 ON READER SERVICE CARD 221



Operator dips parts in HANDY FLUX and assembles them with EASY-FLO 45 rings on a moving rig. Assemblies then pass between banks of gas burners to complete brazing process. Capillary action of EASY-FLO brazing alloy insures thorough penetration—guarantees high strength, leakproof joints.

Flair No. 21 Hot Water Air Vent consists of the basic free-venting air valve, a generous air-collection chamber and a massive hex base. Two preform rings of EASY-FLO 45 are used in the brazing operation. Valve assembly at left was subjected to extreme pressure. Note how body ballooned; joints strong and leaktight.

How Flair Manufacturing Speeds Production, Eliminates Costly Casting With Easy-Flo Brazing

Never a field failure in any joint brazed with EASY-FLO 45 and HANDY FLUX—that's the proud record of Flair Manufacturing Company, Brooklyn, New York, makers of an extensive line of air valves and other specialties for steam and hot-water systems.

Flair finds that brazing with EASY-FLO 45 offers competitive advantages in every aspect of design, production economy and service life. Big savings are made through elimination of costly casting equipment and more productive use of space. Production is smoother, faster. Valves look better, last longer... in tests to 5000 psi, valve bodies burst while brazed joints remain intact. All this for an alloy cost per unit of approximately 2½¢ for two preform rings of EASY-FLO 45.

Speed, strength, economy, low labor costs—advantages *any* manufacturer would be glad to have. And, all achieved through use of Handy & Harman silver alloy brazing. Chances are silver alloy brazing could benefit your product too. If it could, or if you think it *might*, don't hesitate to get in touch with Handy & Harman. We'll help you in every way possible. Why not call us today?

DON'T MISS OUT...
on Handy & Harman's new silver alloy brazing Correspondence Course. Designed to put *all* the facts and techniques at your fingertips, this course is invaluable to everyone concerned with silver alloy brazing. Send for "Training Course Prospectus."

Your No. 1 Source of Supply and Authority on Brazing Alloys

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Shape your product future with U.S. Royalite®

ABS THERMOPLASTIC SHEETS

Here is a versatile thermoplastic sheet material that forms to *any* shape in sharp detail – and still answers the basic design problems of toughness, beauty and economy. Used as a tool for advanced thinking, U.S. Royalite makes new, modern product designs practical. Check these advantages: (1) Royalite is extra tough to resist hard knocks and scrapes, is impervious to grease and oil, nonrusting and unaffected by most chemicals. (2) Royalite molds cleanly, without seams or sharp edges to snag or chip. (3) Royalite gives you new textured beauty in a wide range of colors built in to last. (4) Royalite is extra light, making portable products even more portable. (5) Royalite is economical to use. Advanced fabricating techniques permit its wide use on popular-priced items. Send for free, file-size specifications booklet.

Two of many current applications of U.S. Royalite

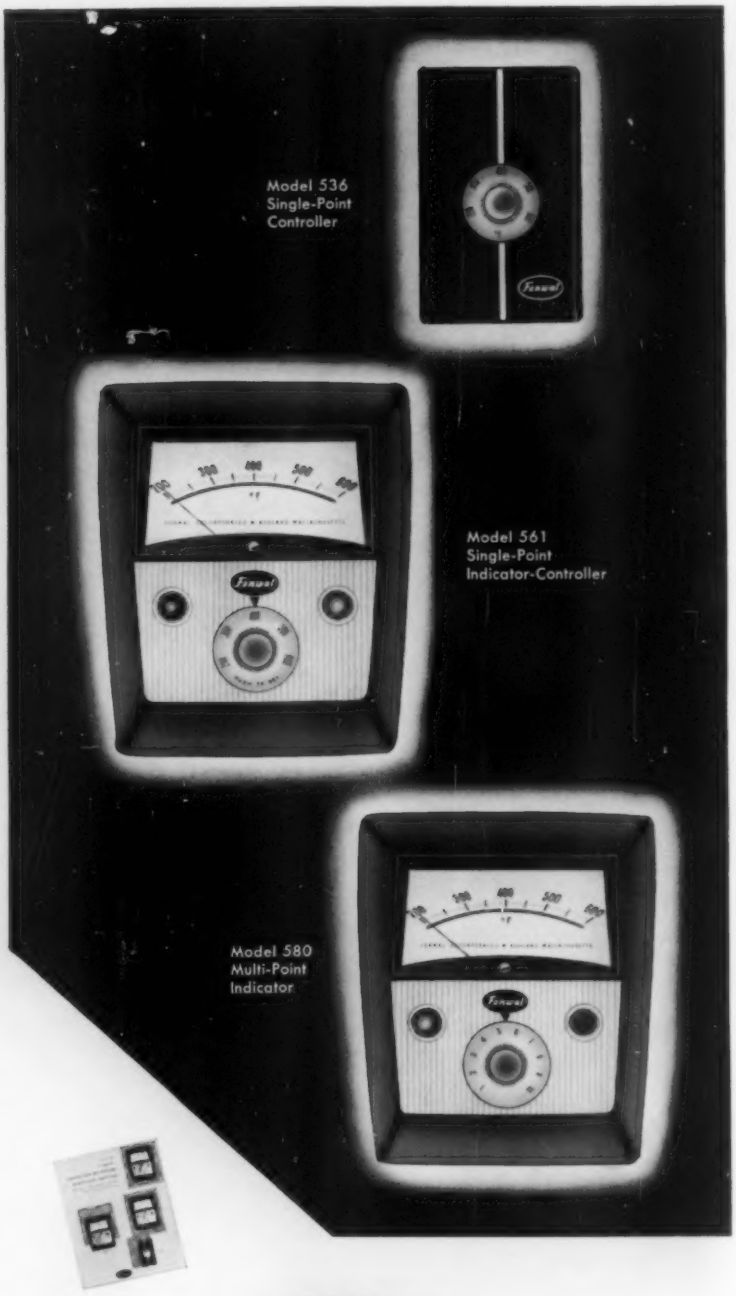
AT THE '60 DESIGN ENGINEERING SHOW — SPACE 1324

US RUBBER

United States Rubber

2688 North Pulaski Rd., Chicago 39, Illinois

NOW... A Better Match for Temperature Control Requirements...



Here's the brand-new family of Fenwal Transistorized Temperature Controllers that lets you order *only* what you need. In addition, you obtain functions previously unavailable in thermistor controllers. These additions to the "500 Line" permit *precise* matching of control instrument to application over a temperature range from −50 to +600°F.

Thermistor sensors and rugged, reliable transistorized circuits assure long life and trouble-free operation... and eliminate lead wire problems. Every instrument is easily installed... in the plant or on the machine. Professionally styled cases and wide choice of colors blend with the most modern surroundings. And, best of all, advanced Fenwal design and production methods keep costs reasonable! Here are three examples:

The Model 536: reliable, single-point controller gives you these options: ON-OFF or proportioning control... set-point adjustment in the instrument or remotely located... indication as well as control... expanded scales for fine temperature adjustment. And you pay only for the option you need. Capacity of 10 amp/110 VAC and 5 amp at 230 VAC.

The Model 561: single point indicator-controller designed for panel mounting. Panel button permits meter display of temperature set point. Control and indication circuits are independent. Mirror-backed scale prevents parallax, tilted glass cover reduces reflection. Option of either ON-OFF or proportioning control. 10 amp/110 VAC relay capacity... insensitive to voltage fluctuations.

The Model 580: multi-point indicator permits "flick of a switch" indication of 2 to 10 temperatures controlled by up to ten Model 536 controllers.

These are just the high spots. For *complete* details on this versatile Fenwal family, send for bulletin MC-190, "Smarter Looking Smarter Acting Electronic Temperature Controls." FENWAL INCORPORATED, 25 Pleasant Street, Ashland, Mass.

Another example of how **Fenwal** CONTROLS TEMPERATURE... PRECISELY

CATALOGS AND BULLETINS

At the 1960 DESIGN SHOW

Literature described below is available at the Design Show (see booth numbers below each item); or may be requested on our regular Reader Service cards, inside back cover. Letterhead requests are on page 243.

PRELUBRICATED BALLBEARING UNITS—Catalog AG-59, 84 pp. Covers complete line of ball-thrust, mounted, clutch-release, roller and special bearings. With specifications, dimensions, ratings and application information. Aetna Ball & Roller Bearing Co, 4600 Schubert Ave, Chicago 39. See Booth 927 or
Circle 357 on Reader Service Card

SELF-RETAINING FASTENERS – Three catalogs, about 10 pp each. Dimensions and application information for a fastener designed for quick assembly of sheet-metal parts, tubing and wiring fasteners, and molding fasteners. Robin Products Co, 27027 Groesbeck Highway, Warren, Mich. See Booth 333 or
Circle 358 on Reader Service Card

GENERAL-PURPOSE CONTROL—Catalog GEC-1260D, 72 pp. Specifications, ratings and application data on motor starters, contactors, pushbutton controls, overload relays, limit switches, solenoids, pilot devices and renewal parts. Illustrated with schematic drawings. General Electric Co, Schenectady 5. See Booth 1724 or
Circle 359 on Reader Service Card

MECHANICAL POWER TRANSMISSION—Catalog SP-59, 136 pp. Covers stock products available, including descriptions, dimensions, ratings and prices. Morse Chain Co, Ithaca, NY.
See Booth 1931 or
Circle 360 on Reader Service Card

PRECISION ELECTRICAL SWITCHES—Catalog 5208A, 32 pp. Presents specifications, characteristics, dimensional drawings and ratings of variety of basic switches and actuators. Includes section on definitions. Licon Div, Illinois Tool Works, 6606 W Dakin St, Chicago.
See Booths 1629-31 or
Circle 361 on Reader Service Card

INDUSTRIAL CONTROLS – Catalog 608.179, 88 pp. Covers general descrip-

continued on page 228

LOW COMPRESSION SET SILICONES!
TECHNICAL MEMO ON LINEAR COMPOUNDS 8441-50, 8444-60, 8439-70 & 8419-80
. . . for static seal applications
• outstanding low compression set properties
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Technical Bulletin No. 56705-1 contains full details —including a list of incompatible fluids. Write today to: Linear Inc., State Road and Levick Street, Philadelphia 35, Pa.
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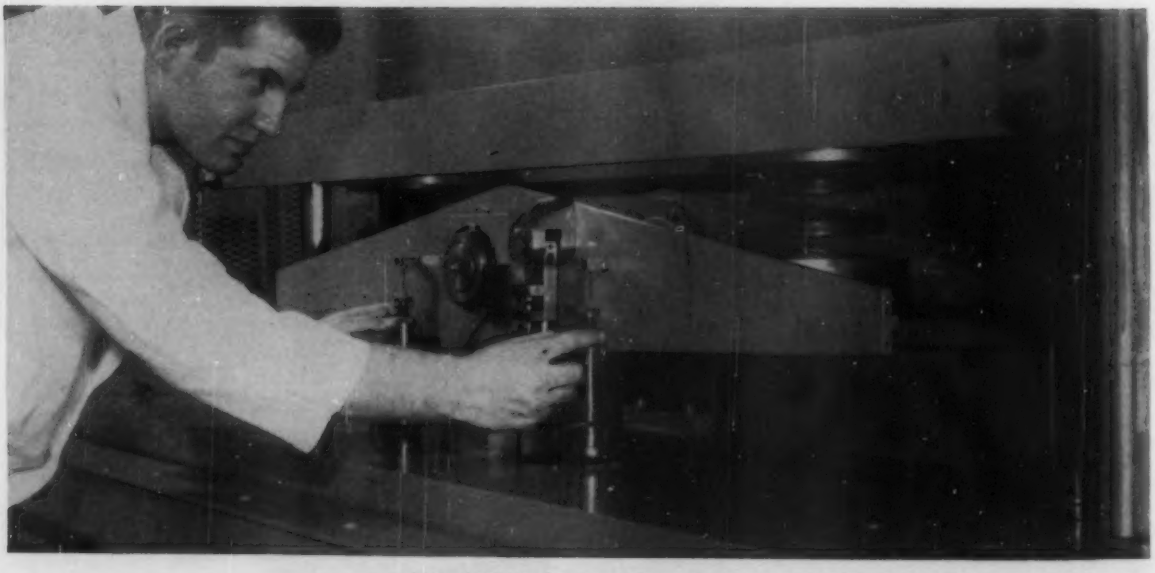
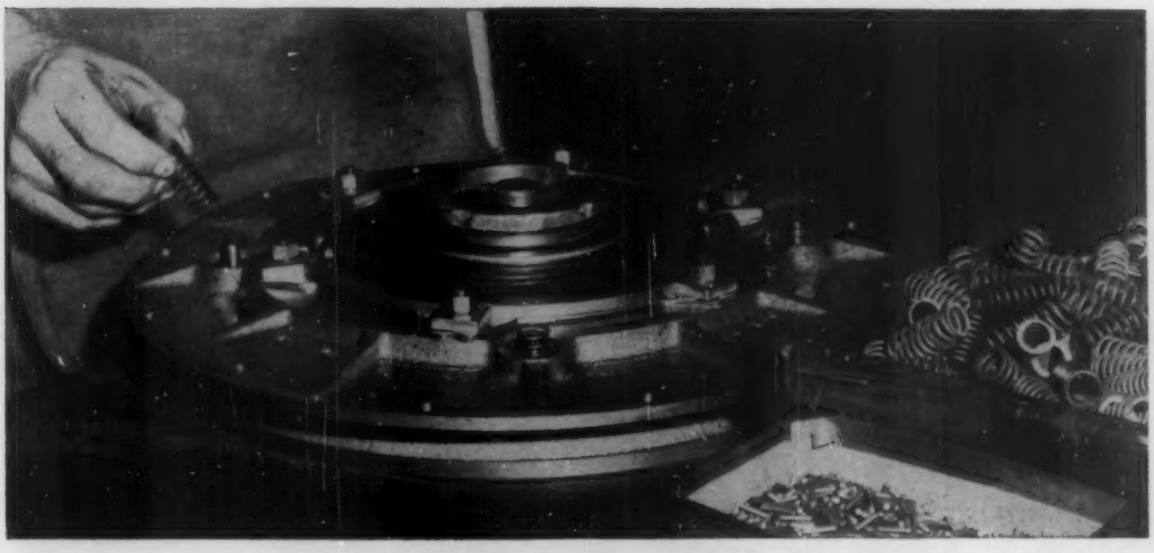
LINEAR, INC. STATE ROAD & LEVICK ST. PHILA. 35, PA.

USS American Springs give longer life,



In the AS&W Spring Laboratory a semi-resonant spring fatigue machine is testing the Lipe-Rollway clutch spring. At speeds of 700 cpm this spring is functioned beyond its normal life span and at higher than normal stresses to prove conclusively its superior design as a clutch spring.

A USS American flat wire compression spring is shown in place in the Lipe-Rollway clutch. Four round wire compression springs are also being installed in the clutch.



better performance in heavy-duty clutches

...thanks to AS&W Spring Engineering Research Service

The Lipe-Rollway Clutch Division, Lipe-Rollway Corporation, Syracuse, N. Y., manufactures automotive clutches for heavy-duty trucks, tractors, buses and other large mobile equipment. Because USS American Springs play a vital part in the performance of these clutches, Lipe-Rollway asked the AS&W Spring Engineering Research Service to test the springs and determine if any changes should be made in the design to improve and maintain the high performance standards.

As a result of these tests the AS&W Engineers recommended certain important changes to give the springs longer life. After this recommendation was adopted by Lipe-Rollway, Mr. Harvey Gray, Chief Inspector & Quality Control, had this to say: "Exceptional service has been realized from our American Steel & Wire Springs."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general office in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steels—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal.

American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.

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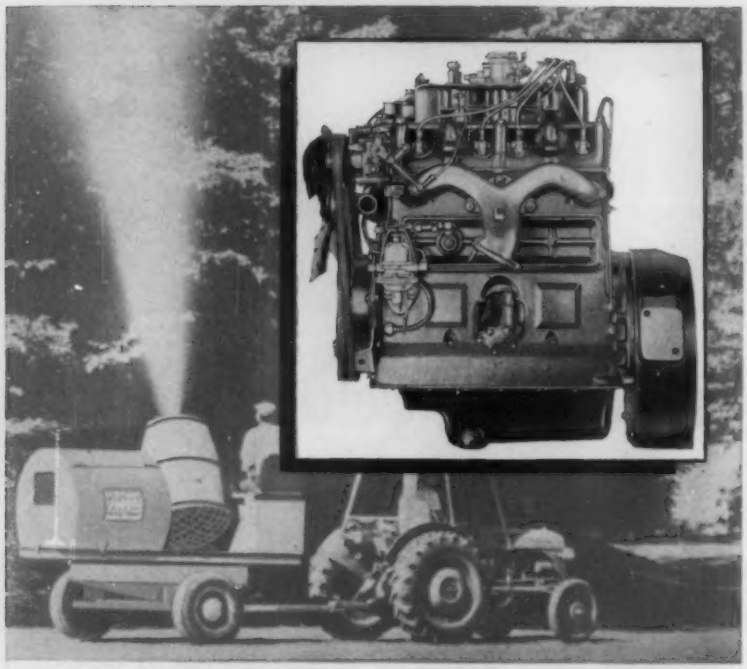
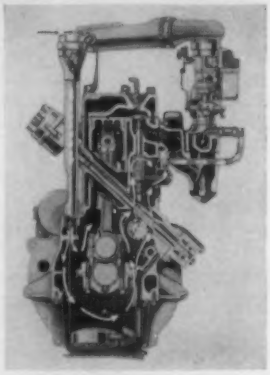


For up to 55 continuous duty hp:

The mighty 4-cylinder 'Jeep' Industrial Engines supply power for hard-working JOHN BEAN sprayer units... just one of the many jobs for which these engines supply extra muscle. Where a tough, *proven* performer is needed, 'Jeep' Industrial Engines have what it takes. The 4-cylinder 'Jeep' is available in an L-head design and a unique, "deep-breathing" F-head design.

KEYPOINT ENGINEERING MAKES THE DIFFERENCE.
'Jeep' Engines are fortified to deliver more power, continuously, than any comparable engine of its size and price. The parts that work the hardest are built the strongest! Among keypoint features are hard chrome compression rings, positive valve rotators, and stellite or eatonite valves... at no extra cost.



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Positive Crankcase Ventilation
The 'Jeep' Engine's ventilating system *automatically regulates* the internal air flow, according to the engine speed. The engine is kept free of dust and dirt, and oil-thinning condensates are quickly removed.

KAISER WILLYS MOTORS

Write for literature and prices
WILLYS MOTORS, INC.
Industrial Engine Dept.
Toledo, Ohio

Manufacturers of 'Jeep' 4 and 6 Cylinder Industrial Engines

tions, specifications, dimensions, applications and performance ratings of various industrial controls. Index lists units by name and by number for ease of reference. General Controls Co, 801 Allen Ave, Glendale 1, Calif. See Booth 1608 or **Circle 362 on Reader Service Card**

QUICK-CONNECT COUPLINGS—Catalog 100, 44 pp. Revised and updated edition presents fluid-line couplings, pressure and vacuum. With specifications, dimensional information and characteristics. Section discusses classification of couplings by type and use. Hansen Mfg Co, 4031 W 150th St, Cleveland 35. See Booth 628 or **Circle 363 on Reader Service Card**

STOCK GEARS—Catalog, about 100 pp. Lists catalog numbers, sizes and prices of stock gears. New catalog has been revised to include such units as Delrin gears. Dynamic Gear Co Inc, 20 Merrick Rd, Amityville, NY. See Booth 1104 or **Circle 364 on Reader Service Card**

CENTRALIZED LUBRICATION—Bulletin 26-T, 24 pp. Features, operating principle and application information on centralized lubrication systems. Farval Corp, 3295 E 80th St, Cleveland 4. See Booth 1337 or **Circle 365 on Reader Service Card**

VIBRATION INDUCERS – Catalog 1041-160, 44 pp plus price list. Presents 52 sizes and types of vibration inducers with specifications, performance characteristics and application information. Martin Engineering Works, Neponset, Ill. See Booth 1903 or **Circle 366 on Reader Service Card**

METAL SPECIFICATIONS—Bulletin 33e, 16 pp. Describes physical properties and chemical composition of various grades of aluminum-bronze alloys of high-aluminum, high-iron type. Also includes information on uses. Ampco Metal Inc, 1745 S 38th St, Milwaukee 46. See Booth 1612 or **Circle 367 on Reader Service Card**

SCREWS AND SPLINES—1960 Engineering data book 60-E, 24 pp. Descriptions, design information and features of ballbearing screw and spline units. Saginaw Steering Gear Div, General Motors Corp, Saginaw, Mich. See Booth 1508 or **Circle 368 on Reader Service Card**

SOLENOID VALVES FOR CORROSIVE APPLICATIONS—Catalog manual 108, 16 pp. Discusses selection factors, valve construction and how to order. Lists corrosive chemicals and recommended

continued on page 232

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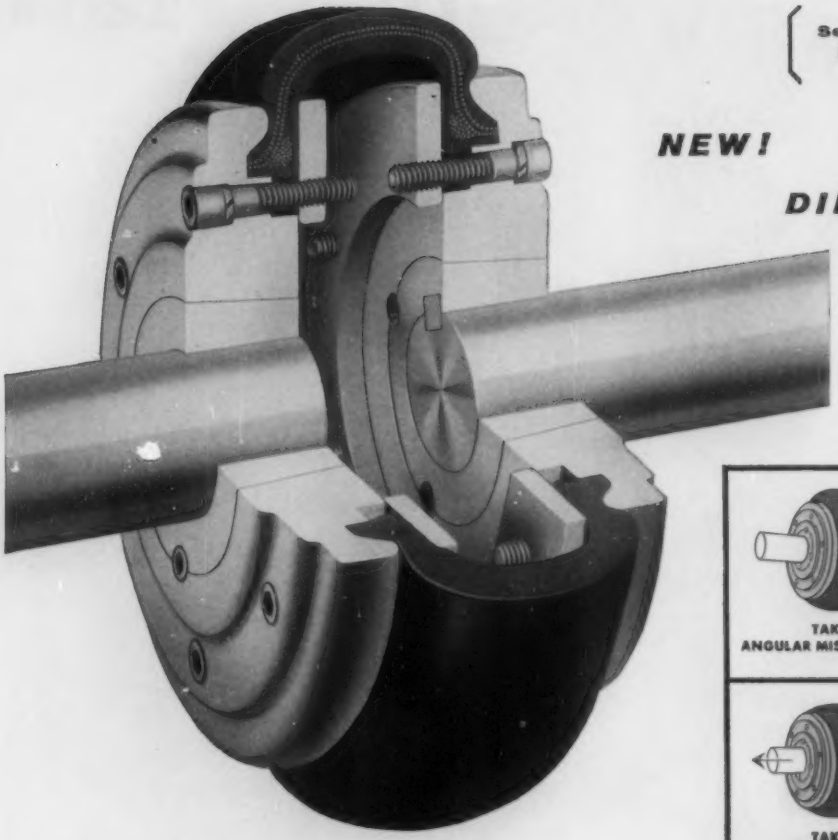

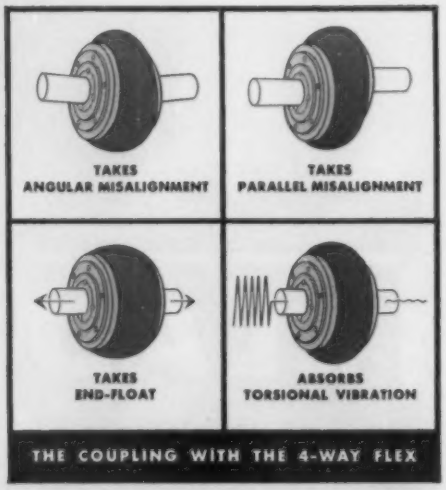

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Para•flex

FLEXIBLE CUSHION COUPLING

THIS coupling "swallows up" shaft misplacements. It automatically compensates for end-float, parallel misalignment, angular misalignment *or any combination of all three.* Moreover, it cushions the stresses of shock loads. And it absorbs torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

Here is a new type of performance—made possible by the development of a tire-like flexing element. Synthetic tension members, bonded together in rubber, give this element the stamina and dependability of modern, high-speed, high-load, shock-absorbing truck tires—and the ability to respond magically to all manner of changing shaft conditions.

Para-flex takes minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. No lubrication is required, no periodic inspection. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine.*

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 2000 hp at 1080 rpm. Call your distributor for a coupling to *make your own test.* You'll witness something revolutionary!

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CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

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fill holes functionally and decoratively

Inexpensive DOT Plug Buttons are ideal for covering drilled or molded holes in metal or plastic structures of all types. Finger pressure snaps them into place, spring tension holds them there without rattling even under conditions of severe vibration.

Used as covers for inspection or maintenance-access holes, Plug Buttons are easily removed and can be re-inserted repeatedly without lessening their effectiveness. Used in combination with plastic lens inserts, Plug Buttons make excellent indicator-light covers. Faceted, Fresnel-type or plain lenses can be made in a variety of colors and can be designed to show words, letters or symbols, according to the requirements of the particular application.

DESIGN ENGINEERING SERVICE

Designers, metallurgists and plastics specialists on DOT's engineering staff are equipped to work out optimum combinations of metal and plastics to suit your particular requirements. Hundreds of variations in shape, finish and material are possible.

The basic steel or brass Plug Button, for example, can be parkerized or polished or finished in chrome, nickel, zinc, copper or any of a wide variety of colored enamels. Designs can be stamped into the metal or molded Lucite lenses can be inserted.

Nylon, polystyrene or flexible polyethylene Plug Buttons can be molded to show trademarks, indicator symbols or any other design.

For further details, write for Engineering Data Catalog, Section D

MAKERS OF DOT FASTENERS

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Catalogs and Bulletins.....continued

valves for each. Valcor Engineering Corp, 365 Carnegie Ave, Kenilworth, NJ.
See Booth 1213 or
Circle 369 on Reader Service Card

ELECTROMAGNETIC CONTROLS AND TIMING DEVICES—Catalog 18-A, 64 pp. Covers construction and operating features, applications and characteristics of various automatic control equipment. Includes wiring diagrams, ratings and prices. Zenith Electric Co, 152 W Walton St, Chicago 10. See Booth 1241 or
Circle 370 on Reader Service Card

FAN-COOLED WORM-GEAR SPEED REDUCERS—Catalog 405, about 22 pp. Describes reducers, gives input horsepower and output torque ratings, service factors and general dimensions. Cleveland Worm & Gear Co, 3293 E 80th St, Cleveland 4.
See Booth 1337 or
Circle 371 on Reader Service Card

CORROSION—Calculator. Sliding table is guide to selection of materials of construction for fluid-control products that handle fluids, including corrosive fluids, under all types of operating conditions. Hoke Inc, 1 Tenakill Park, Cresskill, NJ.
See Booth 1536 or
Circle 372 on Reader Service Card

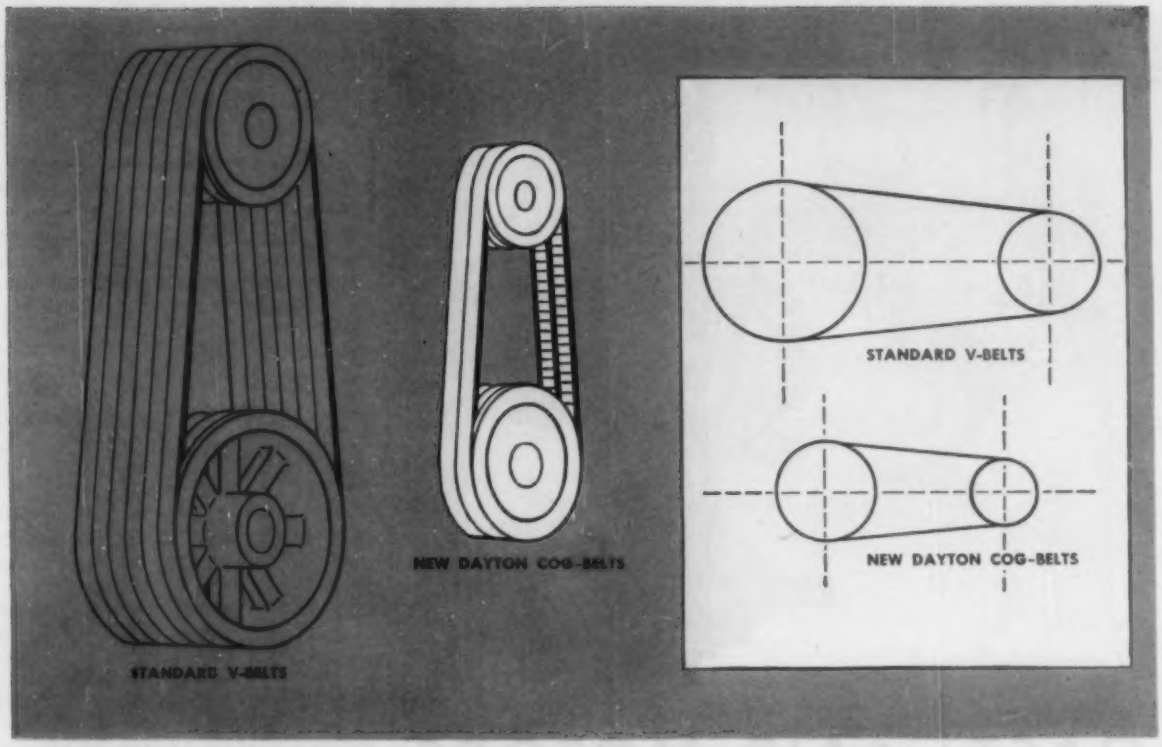
ALLOY-STEEL SCREWS—Catalog 500, 32 pp. Covers dimensions, mechanical specifications and standard sizes. Profusely illustrated with photos and drawings. Mac-It-Parts Co, 275 E Liberty St, Lancaster, Penna. See Booth 1604 or
Circle 373 on Reader Service Card

STOCK PRECISION COMPONENTS—Catalog 61, 512 pp. Presents 20,000 precision stock components, with information on specifications, ratings, dimensions and prices. Sterling Precision Corp, Component Div, 5 Sintsink Dr E, Port Washington, NY. See Booth 2319 or
Circle 374 on Reader Service Card

VARIABLE-SPEED BELTS — Catalog VSB-1, 32 pp; Catalog B-60, 24 pp. Catalog VSB-1 covers features, standards of variable-speed belts; lists applications by number and alphabetically; gives performance information. Catalog B-60 gives specifications, construction information and sizes of belting for V-drives, positive drives and variable-speed drives. Maurey Mfg Corp, 2907-23 S Wabash Ave, Chicago 16.
See Booth 2317 or
Circle 375 on Reader Service Card

DRAFTING-ROOM EQUIPMENT — Catalog GC-59, 24 pp. Describes application, specifications and sizes of drafting tables, filing units, and other drafting and filing equipment. Also covers information

continued on page 234



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Now, possibilities are virtually unlimited for the development of advanced power transmission systems and the improvement of present designs. Dayton's top horsepower rating and superior strength offer these outstanding advantages:

1. **Two Cog-Belts can now do the job of six standard V-Belts . . .** and do it better. Sheave width can be reduced **67%.**
2. **Sheave diameters and center distances can be reduced as much as 30%** due to the extreme flexibility built into the Dayton Cog-Belt.
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Actual on-the-job testing, under the most rugged conditions possible, has proven time and again that Dayton Cog-Belts are unequalled for performance and dependability . . . outlasting other quality belts by as much as 4 to 1. Their extreme flexibility and resistance to oil, heat and static build-up make them ideal for use on high speed drives, or with sub-standard sheave diameters or where oil and heat are factors.

Dayton's exclusive molded raw-edge construction provides tremendous gripping power. Permits operation less tension, resulting in increased bearing life. No special sheaves necessary.

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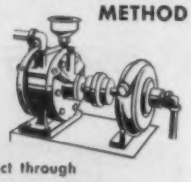

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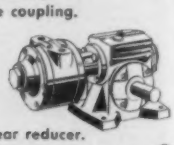

Use gear reducer.

Flange mounted – vertical operation.

Driving pulley.

Need a compact, low-cost motor for original equipment or plant use applications? *Air may be your answer . . .* using one of these efficient Gast rotary-vane Air Motors. Look at the special advantages they offer you:

1. They're explosion-proof — no sparks, no danger!
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8. Amazingly light, compact for h.p. delivered.
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10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

Model No.	1AM	2AM	4AM	6AM	8AM	16AM
H.P. at 90 P.S.I., 2000 RPM	0.13	0.57	1.1	2.0	4.0	7.0
Weight, lbs.	1½	5½	8	17	25	85

For complete performance data, write for Air Motor Bulletins. Specify models that interest you.

GAST MANUFACTURING CORP., P.O. Box 117-V, Benton Harbor, Michigan

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- COMPRESSORS TO 30 P.S.I.
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on tracing equipment. With drawings and photos. Stacor Equipment Co, 285 Emmet St, Newark 5, NJ.
See Booth 2322 or
Circle 376 on Reader Service Card

BREADBOARD COMPONENTS—Booklet 4, 24 pp. Discusses breadboarding and how method is being used in solving instrumentation-development problems. Presents step-by-step review of method. Supplemented by introductory catalog information on breadboard parts. Pic Design Corp, 477 Atlantic Ave, East Rockaway, NY. See Booth 1208 or
Circle 377 on Reader Service Card

PRECISION NEEDLE ROLLERS—Engineering catalog 61, 12 pp. Capacity and design information, ratings, characteristics, general formulae for calculating needle-roller applications and required data for bearing application are included. Kaydon Engineering Corp, Muskegon, Mich.
See Booth 2429 or
Circle 378 on Reader Service Card

UNIVERSAL FASTENERS—Brochure 353, 16 pp. Discusses use of fasteners and their advantages in six actual applications. Tinnerman Products Inc, PO Box 6688, Cleveland 1. See Booth 1226 or
Circle 379 on Reader Service Card

MECHANICAL DIFFERENTIALS—Booklet, 24 pp. Explains what they are, operation, construction and applications. Stock differentials are listed with specifications. Pic Design Corp, 477 Atlantic Ave, East Rockaway, NY. See Booth 1208 or
Circle 380 on Reader Service Card

SPECIFYING SOLENOID VALVES—Brochure, 8 pp. Discusses factors to be considered in selection of proper solenoid valve. With diagrams, performance curves and application drawings. Valcor Engineering Corp, 365 Carnegie Ave, Kenilworth, NJ. See Booth 1213 or
Circle 381 on Reader Service Card

DELRIN PARTS—Bulletin 1001, 8 pp. Covers design considerations in utilizing Delrin molded components. With photos, performance curves and property charts. Gries Reproducer Corp, 125 Beechwood Ave, New Rochelle, NY.
See Booth 2435 or
Circle 382 on Reader Service Card

BALLBEARINGS FOR FARM MACHINERY—Catalog FM100. Divided into such special categories as flange bearings, belt and chain idlers, cam followers, PTO bearings, plunger bearings and wire guides for ease of reference. Includes listing of standard radial bearings adapted to farm-machinery use. Nice Ball Bearing

continued on page 235

Co, Div Channing Corp, 30th and Hunting Park Ave, Philadelphia 40.
See Booth 2321 or
Circle 383 on Reader Service Card

STEPLESS VARIABLE-SPEED CONTROLS—Catalog, 16 pp. Covers specifications, features and ratings of 400 Series. Zero-Max Co, 1900 Lyndale Ave S, Minneapolis 5. See Booth 1640 or
Circle 384 on Reader Service Card

HYDRAULIC PACKINGS – Bulletin P-333, 16 pp. Presents specifications and design information on fabric reinforced and homogeneous hydraulic packings. Crane Packing Co, 6400 Oakton St, Morton Grove, Ill. See Booth 512 or
Circle 385 on Reader Service Card

PRECISION-CAST COMPONENTS – Catalog 10-59, 8 pp. Illustrates and describes design and purchasing information for conventional investment castings and Minicast technique. Discusses both types of castings and what parts should be specified for each process. Cites 14 case studies. Casting Engineers, 2323 N Bosworth Ave, Chicago 14.
See Booth 2334 or
Circle 386 on Reader Service Card

RESEARCH AND DEVELOPMENT FACILITIES—Brochure, 16 pp. Describes and illustrates facilities of Boyle Engineering Laboratory for testing, analyzing and making recommendations for necessary development and research work. Rotherm Engineering Co Inc, 7280 W Devon Ave, Chicago 31. See Booth 2419 or
Circle 387 on Reader Service Card

FASTENING WITH RIVETS—Booklet M-59-2, 12 pp. Classifies types, describes rivet and function. Offers design and production information to permit evaluation and selection of proper fastener. Judson L Thomson Mfg Co, Sawyer Rd, Waltham, Mass. See Booth 625 or
Circle 388 on Reader Service Card

LAMINATED SHIMS—Brochure 59-201, 8 pp. Construction and design features are described. Includes specifications. Laminated Shim Co Inc, 71 Union St, Glenbrook, Conn. See Booth 1221 or
Circle 389 on Reader Service Card

OPEN-END RATCHETING WRENCH—Bulletin 770, 4 pp. Describes operating principles and gives specifications. Bristol Co, Waterbury 20, Conn.
See Booth 430 or
Circle 390 on Reader Service Card

AC CONTROLLED-SPEED SYSTEMS—Brochure F-1963, 8 pp. Explains how system uses ac characteristics to provide
continued on page 236

ANOTHER REASON WHY PARAGON-REVOLUTE QUALITY PAYS OFF FOR YOU!

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Better, faster, more economical prints are what you get as a result of these perforated stainless steel rollers . . . a patented exclusive feature you'll find only in Revolute whiteprinters. The holes allow practically 100% exposure to the developer—at high speeds, low speeds, or fluctuating speeds. Prints travel a shorter route, come through clearer, faster, and there's ¼ to ½ less ammonia consumption than in other designs.

This is just one of the many important advantages in a Revolute Star that pays off for you in more efficient, economical performance. Moreover, you'll find a Star model to meet your printing needs exactly. Printing widths of 24″, 42″ or 54″; top speeds of 45 or 75 fpm.

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Chace THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT

FA QP QUICKLAG CIRCUIT BREAKER

CIRCUIT BREAKER FEATURES . . .

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2. Bi-Metal Thermal Element
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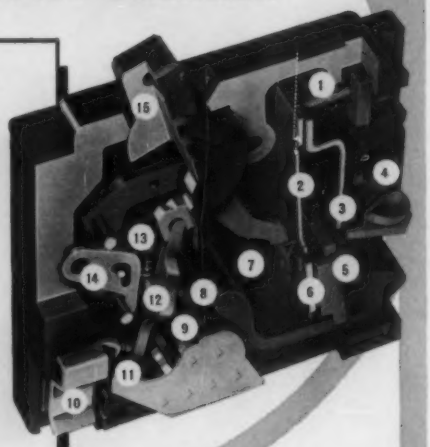
4. Load Terminal
5. Magnet Spring Cushion
6. Hi-Current Magnets
7. Flexible Current Carrying Pig-Tail
8. Cold Cathode Arc Cooling Chamber
9. Cooling Fins
10. Line Side Plug on Contact
11. Electro-Welded Non-Freezing Contacts
12. Tumbling Contact Lever
13. Quick Make and Quick Break Spring
14. Safety Kick Lever
15. Operating Handle



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One of the outstanding features of the Frank Adam Quicklag Circuit Breaker so well illustrated above is the thermal magnetic trip mechanism. It will not trip on temporary overloads. On sustained overloads beyond the safe limit of the wire, the Chace Thermostatic Bimetal element (2) will deflect, causing the breaker to trip. On heavy overloads the deflection of the bimetal reduces the air gap of the magnetic element (5,6) increasing pull of the fixed magnet, resulting in a cooperative action which trips the breaker. Under short circuit conditions, instantaneous tripping is provided by the magnetic elements. Other features are clearly shown above.

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Chace offers over 30 types of bimetal, in strips, coils or completely fabricated elements of customers' designs. When *your* new temperature-actuated device approaches the design stage, send for our booklet, "Successful Applications of Chace Thermostatic Bimetal," containing many pages of valuable engineering and design data.

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adjustable speeds by converting fixed-speed ac motors to adjustable-speeds. US Electrical Motors Inc, Box 2058 Terminal Annex, Los Angeles 54.

See Booths 1704, 1706 or
Circle 391 on Reader Service Card

POSITIVE-DISPLACEMENT PUMPS—Catalog section M, 8 pp; folder SP-509, 2 pp. Catalog section describes line of alloy pumps in capacities from ¼ to 300 gpm. Includes specifications, cutaway views and diagrams. Folder gives specifications, dimensions and performance information on line of small, motor-mounted pumps available in ½-, 1½- and 3-gpm sizes integrally mounted with 1750-rpm motors. Viking Pump Co, Cedar Falls, Iowa.

See Booth 824 or
Circle 392 on Reader Service Card

NEEDLE BEARING—Bulletin S-103, 4 pp. Compares needle bearings with spherical end rollers to bearings employing conical end rollers. With dimensional and capacity information. Kaydon Engineering Corp, Muskegon, Mich.

See Booth 2429 or
Circle 393 on Reader Service Card

GEAR-AND-PINION COMBINATIONS—Bulletin 3001-B, 10 pp. Lists die-cast zinc alloy gear-and-pinion combinations available from stock dies. Includes dimensional information and drawings. Gries Reproducer Corp, 125 Beechwood Ave, New Rochelle, NY.

See Booth 2435 or
Circle 394 on Reader Service Card

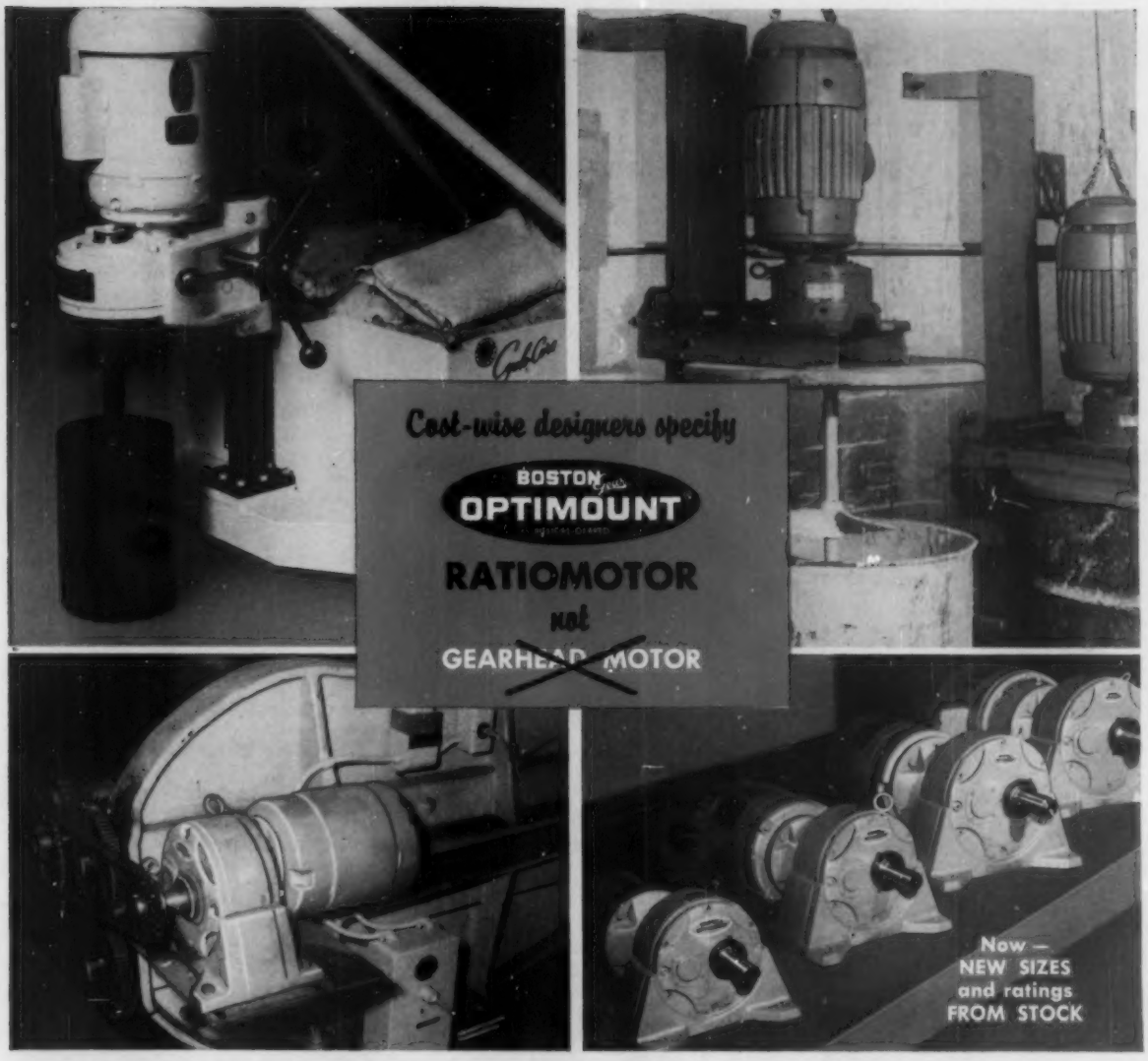
MOTORS—Condensed general bulletin F-1878, 8 pp. Describes and illustrates motor line, with ratings, construction and operational information. US Electrical Motors Inc, Box 2058 Terminal Annex, Los Angeles 54. See Booths 1704, 1706 or
Circle 395 on Reader Service Card

VARIABLE-PITCH SHEAVES, MOTOR BASES—Bulletin SL-101-A, 8 pp. Stock sizes, dimensions and prices for ⅛ to 2 hp drives. Browning Mfg Co, Maysville, Ky. See Booth 2207 or
Circle 396 on Reader Service Card

HYDROFORMING—Brochure 559-1, 8 pp. Discusses method for deep-drawing of metal parts. Typical applications are illustrated and described. Hydroforming Co of America Inc, 7400 W Lawrence Ave, Chicago 31. See Booth 1634 or
Circle 397 on Reader Service Card

TIMING DEVICES—Condensed OEM catalog BX-233, 4 pp; relay catalog, 4 pp. Covers performance, ratings and range of timing devices. With dimensional illustrations. Relay catalog presents descriptions,

continued on page 238



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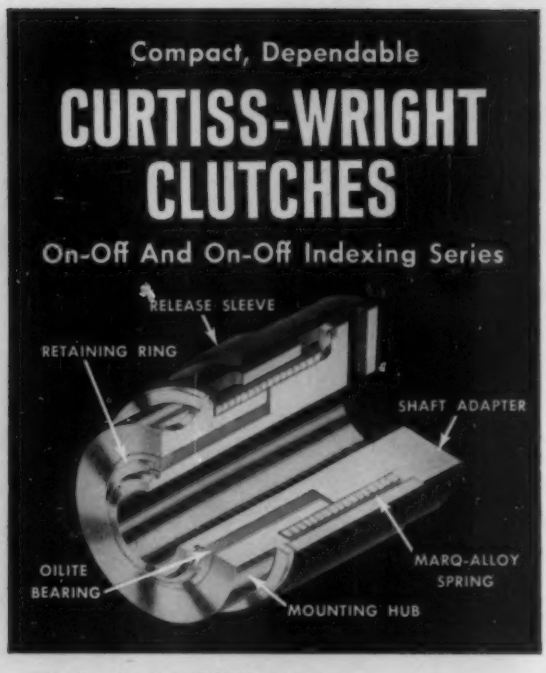

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These clutches are designed for selectively driving and over-running in the same direction. They can be actuated simply by either mechanical or electrical means.

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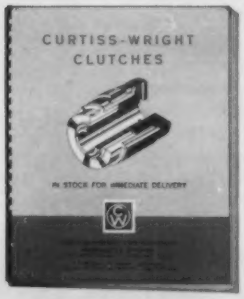

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specifications and dimensions of solenoid-wound, spring-driven time delay relays for special aircraft applications. M H Rhodes Inc, 30 Bartholomew Ave, Hartford 6, Conn. See Booth 2231 or
Circle 398 on Reader Service Card

LIQUID SEALANT FOR METAL PARTS—Brochure 204, 8 pp. Describes methods of application and presents case histories of use. With assembly diagrams. American Sealants Co, 103 Woodbine St, Hartford 6, Conn. See Booth 1009 or
Circle 399 on Reader Service Card

CENTRIFUGAL CLUTCH COUPLING—Bulletin CE-4, 8 pp. Covers features, performance and specifications of automatic centrifugal clutch coupling with flexible action. Hilliard Corp, 100 W 4th St, Elmira, NY. See Booth 1905 or
Circle 400 on Reader Service Card

PROXIMITY SWITCH — Data Sheet 163a, 4 pp. Describes and illustrates sensor and transistor amplifier with plug-in relay. Covers sensitivity range, mounting and wiring instructions, characteristics and operation, as well as price. Micro Switch, Freeport, Ill. See Booth 1202 or
Circle 401 on Reader Service Card

PLASTIC METALLIC MOLDINGS—Bulletin, 4 pp. Discusses use of molding. Includes dimensional drawings. Glass Laboratories Inc, 65th St at 9th Ave, Brooklyn 20, NY. See Booth 1107 or
Circle 402 on Reader Service Card

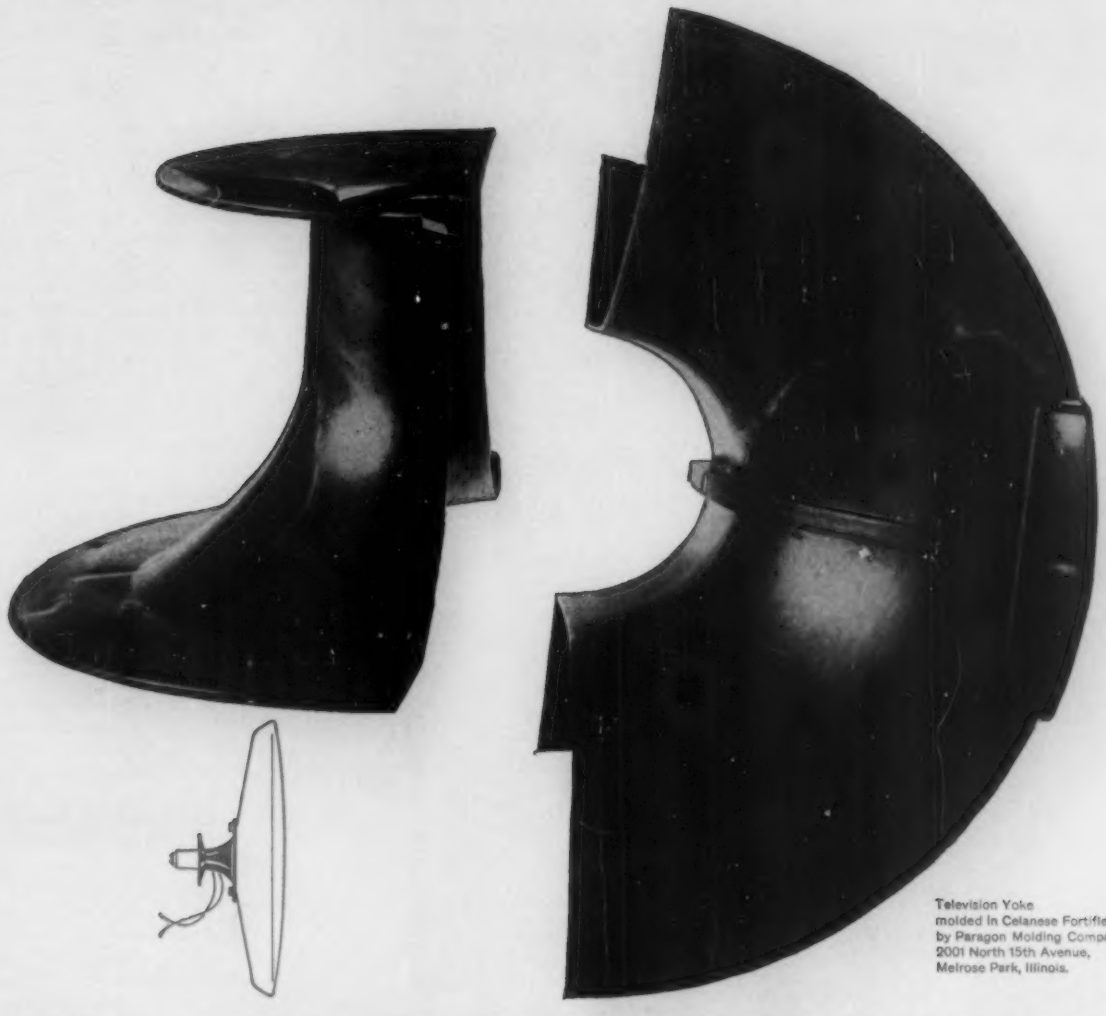
INDUSTRIAL STRONG-BOX SOLENOIDS—Bulletin GEA-62-5B, 12 pp. Design and selection information, force and current curves, specifications and dimensions of industrial strongbox solenoids. General Electric Co, Schenectady 5. See Booth 1724 or
Circle 403 on Reader Service Card

SPEED-REDUCTION DRIVE — Folder F-1994, 4 pp. Features and construction of shaft-mounting speed reducer are shown by cutaway view. US Electrical Motors Inc, Box 2058 Terminal Annex, Los Angeles 54. See Booth 1704, 1706, or
Circle 404 on Reader Service Card

PRESTRETCHED, V-LINK BELTING—Brochure B235B, 4 pp. Describes various types of link-type V-belting. Presents selection and horsepower rating tables. Brammer Corp, 486 Broadway, New York 13. See Booth 1440 or
Circle 405 on Reader Service Card

INSTANT-REVERSING GEARED MOTOR—Brochure 86029, 4 pp. Cutaway illustration presents design and features of motor controlled by built-in adjustable

continued on page 240



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molded in Celanese Fortiflex
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NOW...THREE FLAME RESISTANT FORTIFLEX FORMULATIONS

New flame resistant Fortiflex is used as insulation in television yoke

In view of the increasing use of Fortiflex A linear polyethylene in electrical appliances where fire hazards can occur, Celanese now offers this material in three flame resistant formulations:

- **FORTIFLEX A-70-12**
- **FORTIFLEX A-250-12**
- **FORTIFLEX A-500-12**

These formulations provide a spread of melt indexes (0.7, 2.5 and 5.0 respectively), making it possible to mold a wide variety of flame resistant products. They are recommended for use in room air conditioners, refrigerators, electric motors, television sets, etc.

Flame resistant Fortiflex formulations are high density polyethylenes with a specific gravity of 1.04. They are available in opaque, white and black. Their stiffness, hardness and tensile strength are approximately the same as for standard Fortiflex A. However, heat distortion values under 66 psi are slightly lower and impact strength is somewhat reduced. Most important of all, the materials are self-extinguishing: burning rate or flammability is reduced to the point where they can be classified as non-burning materials under ASTM D-635-44.

Use Fortiflex flame resistant formulations wherever a self-extinguishing material is required.

More information is available. Write today for New Product Bulletin NP-35. Celanese Plastics Company, a Division of Celanese Corporation of America, Dept. 103-E, 744 Broad St., Newark 2, N. J. Celanese® Fortiflex®

Canadian Affiliate: Canadian Chemical Company, Ltd., Montreal, Toronto, Vancouver. Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Ave., New York 16.

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limit switches. Automatic safety devices reverses motor rotation whenever predetermined resistant force is encountered by driven product. Typical application is shown. **Franklin Electric Co Inc, 400 E Spring St, Bluffton, Ind.**

See Booth 1705 or
Circle 406 on Reader Service Card

HIGH-PRESSURE PLASTIC LAMINATES—Industrial leaflet 168F, 4 pp. Specifications of industrial laminates are tabulated. Includes sizes, tolerances and application information. **Farley & Loetscher Mfg Co, Plastics Div, 7th and White Sts, Dubuque, Iowa.** See Booth 405 or
Circle 407 on Reader Service Card

SELF-BONDING NAMEPLATES—Bulletin 161-A, 4 pp. Discusses applications and design features. With specifications and ordering information. **W H Brady Co, 727 W Glendale Ave, Milwaukee 9.**
See Booth 1734 or
Circle 408 on Reader Service Card

FOOTSWITCHES—Bulletins (3), 2 pp each. Specifications and characteristics of rheostat footswitch, wide-treadle footswitch, two OEM footswitches and footswitch with heavy tread on actuating treadle. **Linemaster Switch Corp, Woodstock, Conn.** See Booth 1224
Circle 409 on Reader Service Card

C-FACE SPEED REDUCERS—Bulletin 5-250, 6 pp. Features, specifications and ratings of C-face speed reducers. With dimensional drawings. **Jannette Electric Mfg Co, Lehigh at Main, Morton Grove, Ill.** See Booth 626
Circle 410 on Reader Service Card

SOCKET SCREWS—Bulletin 769, 6 pp. Lists socket screw specifications according to new dimensional standards. **Bristol Co, Waterbury 20, Conn.** See Booth 430 or
Circle 411 on Reader Service Card

PANEL-WIRING CHANNEL—Bulletin S-305, 8 pp. Discusses advantages of this method of wiring, illustrates installation, and gives specifications of panel units and accessories. **Stahlin Bros Inc, Belding, Mich.** See Booth 2003 or
Circle 412 on Reader Service Card

VINYL-METAL LAMINATE—Brochure, 8 pp. Explains how vinyl is bonded permanently to metal, features, performance information and typical applications. **Clad-Rex Corp, Sub of Simoniz Co, 2101 Indiana Ave, Chicago 16.** See Booth 932 or
Circle 413 on Reader Service Card

COMPRESSORS AND VACUUM PUMPS—Data Sheets, 12 pp. Loose-leaf pages describe Series OP compressors and

continued on page 243

Alemite Accumite® Centralized Lubrication System avoids costly breakdowns, work-stoppage. Automatic positive lubrication protects all machines!

The Alemite Accumite® Centralized Lubrication System comes complete with pump, metering valves and controls. Meters exact amount of lubricant to all bearings whenever system is operated by air, vacuum or manually at any predetermined frequency.

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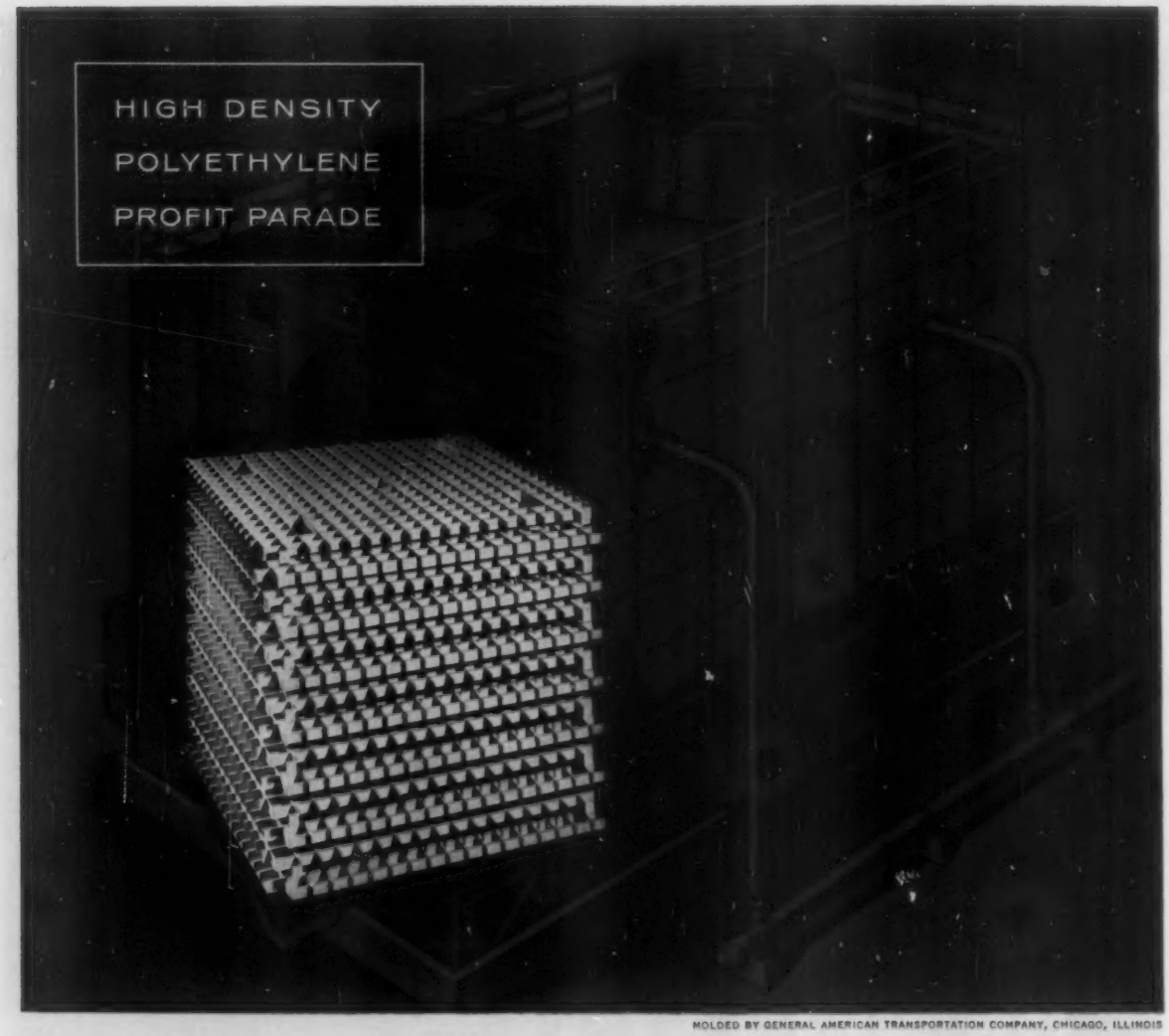

MOLDED BY GENERAL AMERICAN TRANSPORTATION COMPANY, CHICAGO, ILLINOIS

New Plastic Cooling Tower Grids Last Longer—Cool Better

Are you working on a new way to improve the performance of your products? Grex high density polyethylene could be the best material for your application, just as it is for the superior cooling tower grids developed by Fluor Products Company.

Fluor "Poly-Grid" takes the place of a wooden egg crate construction in film-type tower packing. As water cascades through this type of packing it is broken into a continuous film to permit evaporation and cooling. Efficiency is improved by increasing the surface area of the packing with thinner strips and more spaces between them. This principle is applied by "Poly-Grid" to provide more cooling per cubic foot than any other packing.

The grids molded of Grex are designed for use in water cooling systems contaminated by chemicals. This Grace plastic is impervious to corrosive action of most chemicals. The grids utilize the strength and rigidity of Grex in moldings that cover an area of up to 9 square feet. They are light in weight. Compared to wooden tower packing, they require far less maintenance and are much more durable. As Fluor engineers put it, "Poly-Grid" can be considered to have a longer service life than any other cooling tower fill material now in use.

Find out more about high density polyethylene for improved products in your field by calling in the experts. Grace has the production facilities, technical service and experience to help put your products in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

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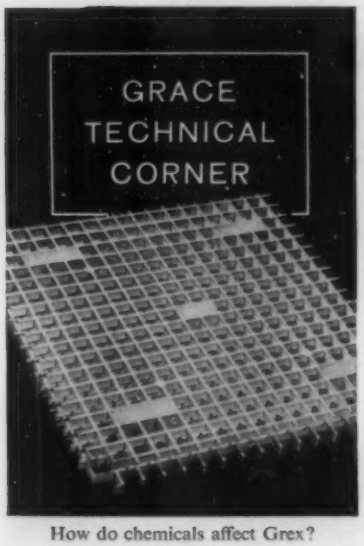

How do chemicals affect Grex?

From the standpoint of resistance to chemical attack, high density polyethylene is perhaps the most versatile plastic available today for consumer and industrial products. Grex withstands staining, embrittlement, permeation, softening and distortion when exposed to many different liquids and gases normally harmful to other materials. A key reason why Fluor chose Grex for "Poly-Grid" is the fact that it cannot be damaged by such chemicals as hydrocarbons present in industrial water cooling systems. Similar problems have been solved for a wide range of other products by specifying this plastic. Here are a few examples.

Industrial chemicals. Five-gallon carboys for shipment of virtually all corrosive alkalies and acids are made of high density polyethylene.

Agricultural chemicals. A fertilizer spreader for home gardeners and a fitting for an agricultural sprayer are made of Grex to withstand attack of agricultural chemicals.

Salt water. Marine rope, a fishing tackle box and a marine battery case are made of high density polyethylene to withstand harmful effects of sodium chloride and other chemicals in salt water.

Petroleum products. A jerry can blow molded of high density polyethylene is unaffected by most petroleum products.

Chlorine. The valve for a home swimming pool chlorine pump utilizes Grex to resist corrosion.

Get more details. Send for the new Grace Technical Service Bulletin, No. 104, "Chemical Resistance of Grex." And remember that Grace is ready and willing to provide technical assistance for your high density polyethylene projects. Bring us into your picture soon.

Technical Service Department
W. R. Grace & Co., Clifton, N. J.

Catalogs and Bulletins.....continued

Series OV vacuum pumps, with application information, specifications and performance curves. **Gast Mfg Corp, Benton Harbor, Mich.** See Booth 925 or
Circle 414 on Reader Service Card

REVOLVING AND EXPANSION JOINTS—Catalog 14, 12 pp. Specifications, features, dimensions and dimensional drawings, and mounting, design and construction information. **Rotherm Engineering Co Inc, 7280 Devon Ave, Chicago 31.** See Booth 2419 or
Circle 415 on Reader Service Card

MINIATURE AND FLOATING FASTENERS—Data sheets M and AS, 1 p each. Dimensional information and drawings, with specifications of the self-clinching fasteners. **Penn Engineering & Mfg Corp, Box 311, Doylestown, Penna.**
See Booth 1023 or
Circle 416 on Reader Service Card

PLASTIC WIRING DUCTS – Bulletin D-2, 14 pp. Design and construction information, application data and dimensions of various types of plastic, snap-cover wiring ducts. **Panduit Corp, 14461 Waverly Ave, Midlothian, Ill.** See Booth 409 or
Circle 417 on Reader Service Card

SPRING-LOADED PULLEYS – Catalog SL-1, 4 pp. Descriptions, dimensions, specifications and drive selection charts for spring-loaded pulleys and compounded drives. Also contains belt selection and center distance charts for compound drives. **Maurey Mfg Corp, 2907 S Wabash Ave, Chicago 16.** See Booth 2317 or
Circle 418 on Reader Service Card

HAMMER-DRIVEN BLIND RIVETS—Bulletin 227, 6 pp. Describes and illustrates dimensions and applications of fasteners. **Star Expansion Industries Corp, Mountainville, NY.** See Booth 1234 or
Circle 419 on Reader Service Card

LOW-COST PUMP LINE – Bulletin 2014-B2, 4 pp. Design features, operation and performance information and dimensions. **Worthington Corp, Standard Pump Div, Harrison, NJ.** See Booth 316 or
Circle 420 on Reader Service Card

MINIATURE BALLBEARINGS—Catalog 2-E-1, 4 pp. Covers dimensions, load factors, ball sizes and weights of sealed and open-radial, flanged-radial and pivot-type miniature ballbearings. **Landis & Gyr Inc, 45 W 45th St, New York 36.**
See Booth 1830 or
Circle 421 on Reader Service Card

TENSION AND TORQUE CONTROLS—Brochure, 6 pp. Contains descriptions and application information for general motion and servomotor controls for webs and filaments. **Web Controls Corp, 318 Briarcliffe Rd, W Englewood, NJ.**
See Booth 1729 or
Circle 422 on Reader Service Card

COUPLING ACCEPTS MISALIGNMENT—Bulletin 62, 2 pp. Features, construction information and dimensions of coupling with rigid hub that accepts up to 5° shaft misalignment for each set of gear teeth. **John Waldron Corp, PO Box 791, New Brunswick, NJ.**
See Booth 2200 or
Circle 423 on Reader Service Card

SHELL INVESTMENT CASTING—Brochure, 4 pp. Gives advantages of new casting technique over conventional method. **Engineered Precision Casting Co, PO Box 68, Matawan, NJ.**
See Booth 909 or
Circle 424 on Reader Service Card

SPEED REDUCERS—Catalog HM-60, 18 pp. Covers specifications and description of motorized planetary-type speed reducers. **Winsmith Inc, Eaton St, Springville, Erie County, NY.**
See Booth 528 or
Circle 425 on Reader Service Card

POROUS CERAMIC FILTER ELEMENT—Bulletin GEO-515A, 4 pp. Presents properties and use of filter element, which is fabricated of special glass formulation. **Commercial Filters Corp, 2 Main St, Melrose 76, Mass.** See Booth 504, or
Circle 426 on Reader Service Card

LETTERHEAD REQUESTS ONLY
Manufacturers who published following literature asked that requests for copies be made on company letterheads.

PRINTED CIRCUIT BOARDS—Bulletin CE-3.00, 2 pp. Reports characteristics of printed circuit boards made of glass-ceramic material. **Corning Glass Works, Corning, NY.** See Booth 1507

STRUCTURAL ADHESIVES – Catalog, 16 pp. File-tabbed publication covers structural adhesives, structural-adhesive design concepts, joint designs and bonding methods. Back cover has integral envelope for filing future data sheets. Case histories illustrate applications. **Adhesives, Coatings and Sealers Div, Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6.**
See Booths 1718 and 1720

CUSTOM EXTRUSIONS—Brochure, 72 pp. Discusses design and applications of extrusions. One section presents more than 700 cross-sections of extrusions. **Anchor Plastics Co Inc, 36-36 36th St, Long Island City 6, NY.** See Booth 2103

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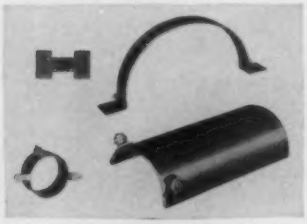

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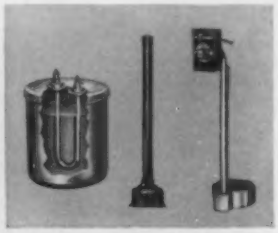
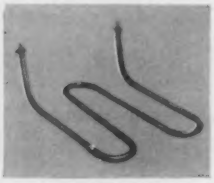
Straight or curved. Diameter ¾" to 2", any length, with capacities to 10,000 watts.

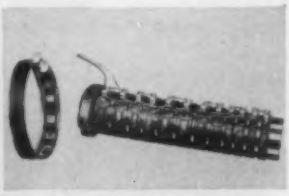




Watlow TUBULAR HEATERS

Available in sheath materials for all purposes . . . various terminals to meet special needs . . . in most voltages . . . in standard as well as odd lengths, diameters and wattages.

Watlow NARROW-BANDED HEATERS



Patented clamping band. Widths 1 to 2", diameters 1⅝" and up. Watt densities up to 45 watts/sq. in. Standard cylindrical heaters in a wide variety of widths and diameters.

■ *Write for* FREE CATALOG *and let us help solve your electric heating problems.*

WATLOW
ELECTRIC MANUFACTURING CO.
1392 Ferguson Avenue
St. Louis 14, Mo.

SIGNIFICANT COMPONENTS, MATERIALS, PROCESSES

Following new products are not to be exhibited at the Design Engineering Show. However, further information can be obtained, as usual, by circling corresponding number on Reader Service Card.

Cartridge-type insert valves . . .

are installed inside pneumatic or hydraulic devices that they control. Four models are now in production, including ⅛- and ¼-in. sizes, for two- and three-way service, actuated manually, mechanically, electrically or by pilot. As many as 15 cartridge valves can be combined into single module measuring a few inches square, fed by single supply line and with common exhaust. Valves, with built-in quick exhaust, may be used for heavy-duty service, for continuous cycling at speeds up to 30,000 per hr. **Humphrey Products Div, General Gas Light Co, Kalamazoo, Mich.**

Circle 427 on Reader Service Card

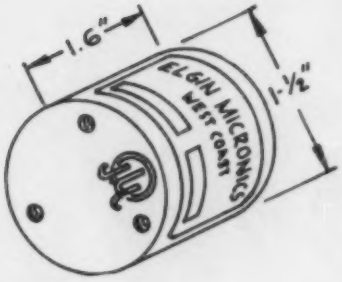
High-heat coatings . . .

are available in 18 colors for color coding or complete finishing of metal components subjected to temperatures from 600 to 1700 F. Most colors contain combination of non-leafing aluminum and special metallic pigment. Non-leafing particles are said to remain equally distributed and in constant suspension with pigment. Provides uniform coverage in the applied coat. Colors offered are aluminum, metallic

continued on page 245

gold, metallic blue, metallic red, white, light red, orange, light, medium and dark chrome green, black, dark gray, brown, ferrite yellow, chrome yellow, light, medium and dark blue. Available in 1 qt, 1 gal. and 5-gal. cans. **Speco Inc, 7308 Associate Ave, Cleveland 9.**

Circle 428 on Reader Service Card



Inertia switch . . .

is electrical contact closure-delay device that functions when acceleration forces of appropriate magnitude, direction and duration are sensed. Can be modified for wide range of acceleration and timing values. Upon application of acceleration forces of sufficient duration to complete time function, switch will remain in operated condition until manually reset to safe. Acceleration range is from 14 to 72 g. Depending upon acceleration, delay times are 0.55 to 1.65 sec. Accuracy is said to be ±200 millisec variation at rated acceleration. Operates in −40 to 165 F. Withstands vibration of 15 g at 5 to 2000 cps; shock of 100 g for 10 millisec duration. Weighs 3¼ oz. **Elgin Micronics, Chatsworth, Calif.**

Circle 429 on Reader Service Card

Abrasion-resistant die steel . . .

is now available in stock rounds from ¼ to 14 in.; flats from ¼ x ¼ to 4 x 6 in.; squares from ¼ to 8 in.; square billets from 4 to 12 in. Steel is also available in forgings. High-carbon, high-chromium, air-hardening, free-machining die steel provides high resistance to edge wear and chipping. **Darwin & Milner Inc, 2222 Lakeside Ave, Cleveland 14.**

Circle 430 on Reader Service Card

Adjustable-pulse switch . . .

for industrial applications where momentary opening and/or closing of circuit is necessary. Particularly suited to control pneumatic valves where permanent-duty solenoids are not used. Pulse operation occurs as plunger is depressed. No switch-

continued on page 246

50,000 HOURS

of silent, synchronous power assembled in every *

HANSEN SYNCHRON® TIMING MOTOR

Manufacture of long-life, Hansen SYNCHRON Timing Motors is quality-controlled throughout, to make them the *best* synchronous motors for industrial and commercial applications. Skilled, experienced workers assemble Hansen SYNCHRON motors to rigid standards. Each motor undergoes 51 separate tests and inspections before shipment, insuring users of the ultimate in silent, continuous, synchronous power for specific timing applications.

Operating efficiently in any position, self-starting, self-lubricating Hansen SYNCHRON Timing Motors deliver from 8 to 30 in./oz. guaranteed torque; at temperatures from —40 F to +140 F; in speeds from 600 rpm down to ½ rph; clockwise or counterclockwise rotation. Over 200 types of output available.

The efforts of Hansen engineers have been concentrated in just one area for over 50 years — creating and applying synchronous power units to timing applications. Use this experience to solve your specific timing problems. Contact your nearest Hansen representative, or write direct.

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Schenectady, N. Y.

ELECTRIC MOTOR ENGINEERING, INC.
Los Angeles, Calif. (OLive 1-3220)
Oakland, Calif.

WINSLOW ELECTRIC CO.
New York, N. Y. • Chester, Conn.
Philadelphia, Penn. • Cleveland, Ohio

*An average figure for Hansen SYNCHRON Motors . . . many are designed for shorter life — others for years longer.

HANSEN MANUFACTURING COMPANY, INC.
PRINCETON, INDIANA

NEEDED:
ISOLATION FROM
HIGH ENGINE TORQUE
AND SHOCK

...to isolate frame and operator from the high engine torque, shock and violent bursts of intermittent power delivered by the engine on a 6-ton crawler-tractor; also to protect engine from shock of heavy pounding.

ANSWER:
STANDARD
MB ISOMODE (tm)
TYPE 5 MOUNTS

The Isomode Type 5 Mount isolates equally the six possible modes of vibratory motion. With core in balanced compression and shear, it offers high load capacity and endurance in compact size. It is safely self-snubbing to control damaging overloads. And it can take an extraordinary amount of punishment.

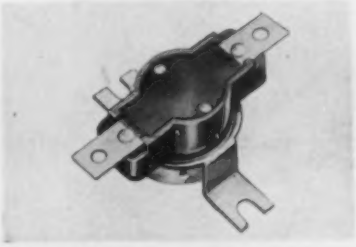
WHAT'S YOUR
MOUNT PROBLEM?

MB has specialized in vibration isolation for over 20 years. It may very well be that an existing standard MB mount or modification thereof is the answer to your vibration control problem. If not, MB has the experience and personnel to find the right answer for you. Write us for complete information—ask for Bulletin 418-1.

MB ELECTRONICS
A DIVISION OF TEXTRON ELECTRONICS, INC.
1076 State Street, New Haven 11, Conn.

ing action takes place on plunger return stroke. Pulse length is adjustable from 0.030 to 0.450 in. Mechanical characteristics include 0.150-in. max pretravel; 0.600-in. min total plunger travel, 4-lb operating force and 8-lb full overtravel force. Switch is sealed against oil, water, dust and dirt. SPDT unit is rated 10 amp at 125, 250 or 480 v ac; ½ amp at 125 v dc; ¼ amp at 250 v dc. **Micro Switch, Freeport, Ill.**

Circle 431 on Reader Service Card



Disk-type thermostat . . . offers snap-action temperature control in air-conditioning, heating and ventilating equipment, dryers and unit heaters. Actuated by snap-acting disk, ¾-in. units are UL-tested for high-capacity switching action at ratings to 25 amp, 240 v ac, resistive, and for accurate temperature repeatability over 100,000 operating cycles. Switch mechanism is enclosed in phenolic case. Available with fixed temperature settings up to 30 F. Models in series operate either as limit switches or fan switches. Automatic-recycling and manual-resetting types are offered. For mounting, terminal axis can be positioned at various angles with respect to flange axis to provide max electrical clearance in mounting. **Texas Instruments Inc, Metals & Controls Div, 34 Forest St, Attleboro, Mass.**

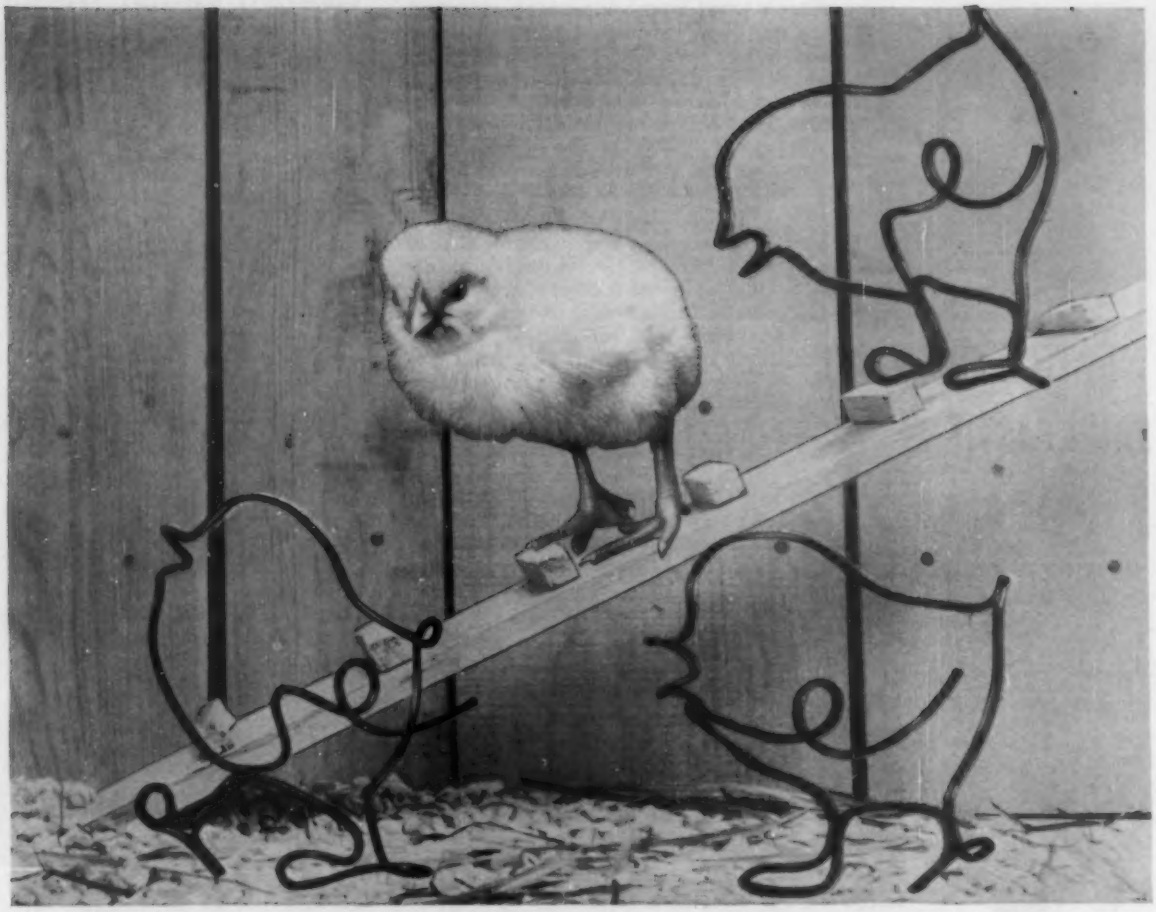
Circle 432 on Reader Service Card

Cast-iron standard shapes . . . and forms are available for immediate delivery. Rounds, flats, squares, tubes, disks, gear links, angles, tees, channels and hexagons in sizes from ¼ to 60 in. are offered. **Standard Foundry Products, 412 Laurel St, Reading, Penna.**

Circle 433 on Reader Service Card

One-part protective coating . . . offers dielectric strength of about 1700 v per mil and dielectric constant of 2.5. Said to have excellent moisture-proofing properties with outdoor durability. Drying time to handle is 10 min. while complete drying time at room temperature is 2 hr.

continued on page 248



Bundy can mass-fabricate practically anything

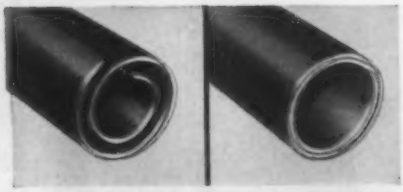
Bundyweld®—the original double-walled steel tubing—is ideal for everything from simple bends to complex shapes

The old adage, "Don't count your chickens before they hatch," is a good one . . . but it rarely applies to Bundy. That's because, no matter how complex your tubing problem, you *can* count on Bundy for the perfect solution.

Bundy engineers and designers are backed by years of experience in the mass-fabrication of steel tubing. And they are available to you at any stage of product development for time- and money-saving suggestions. Their key: Bundyweld®!

Bundyweld steel tubing is double-walled, copper-brazed, stronger, with higher bursting and fatigue strengths. That makes Bundyweld the safety standard in small-diameter tubing—and a wise choice for a wide variety of tubing applications! Covered by Government Spec. MIL-T-3520, Type III.

So, when you want to talk tubing, talk to the leader—Bundy! Phone, write, or wire Bundy Tubing Company, Detroit 14, Michigan.



Bundyweld is the original tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ⅝" O.D.

There's no substitute for the original Bundyweld Tubing.

BUNDY TUBING COMPANY

HOMETOWN, PA. • DETROIT 14, MICH. • WINCHESTER, KY.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

Discharge Valve

SWITCH FROM SAND CASTINGS TO BRASS FORGED PARTS

Here's why! Your component parts forged of Titan brass will outperform any you now buy as sand castings. No more costly rejects due to blow holes and sand inclusions. Eliminate leakage and other product failures. The twice-wrought metal in brass forgings has the inner toughness and density to give you new strength and workability. Thinner sections can be used.

Tensile strength is almost double that of most sand castings. Closer tolerances, dimensional uniformity of production lots, and superior finish unknown in sand castings are routine in Titan forgings. For you this means faster chucking and better machinability—threads can often be chased on the forging without preliminary forming. And you have less scrap and less finishing cost prior to plating.

In a Titan forged part you get greater eye appeal to help sell your product. Look at the smooth surface of these forgings to see what we mean; each was once a rough sand-cast part.

May we say more? Call your nearest Titan office for detailed information and a brass forging quote on your sand-cast parts.

Titan® METAL MANUFACTURING COMPANY

DIVISION OF CERRO DE PASCO CORPORATION

Bellefonte, Pa. • Newark, Calif.

Offices & Agencies in Principal Cities

RODS • WIRE • FORGINGS • DIE CASTINGS • WELDING RODS

45 Years of Quality Brass

Send for 32-page Titan Forging Handbook. Write us on your letterhead.

Conduit Coupling

Main Valve Control

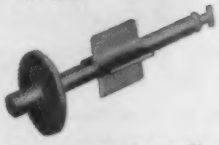
Heat Exchanger Head

Gauge Socket

Air Compressor Part

Main Valve Seat

Storm Door Handle


Lavatory Pop-up Plug

Coating is applied by dip or brush method and yields buildup of 2 mil min per application. Suitable for continuous application in temperatures in excess of 266 F. Columbia Technical Corp, 61-02 31st Ave, Woodside 77, NY.

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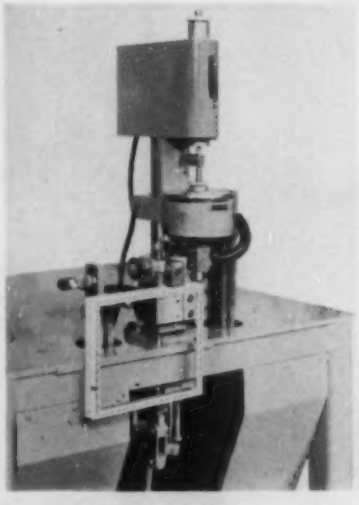

Magnetic-force welding of prepainted steel . . .

is now possible with refinement of precision resistance-welding method originally developed for vinyl-laminated steel. Steel precoated with paints, vinyl plastisols, acrylic finishes and wood veneer may be joined by this method. Because these coatings can be damaged by temperatures over 300 F, very short welding time is required. Welding machines range from $5000 to $8000, depending upon application. (Shown is picture-frame welder.) Delivery, 6 to 10 wk. **Precision Welder and Flexopress Corp, 3520 Ibsen Ave, Cincinnati 9.**

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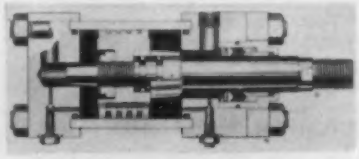
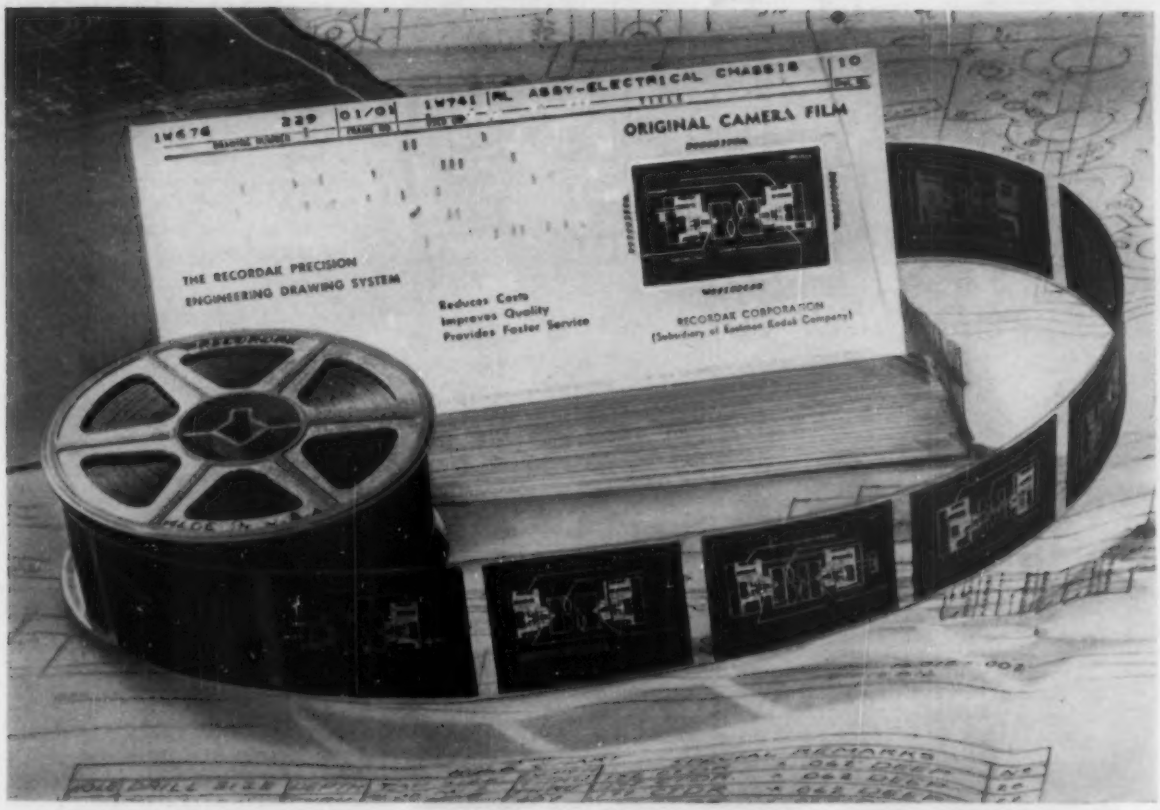


Hydraulic cylinder line . . .

is said to meet JIC standards for interchangeability. Features include cartridge rod bearing that incorporates metal rod-scraper plus rubber rod-wiper. Cartridge rod bearing can be removed without removing cylinder from mount and without disassembling cylinder. Bearing has spring-

continued on page 250



Take the "wait" out of reference and printmaking with Recordak microfilming!

Needle-sharp Recordak microfilm images mounted on Filmsort aperture cards are speeding routines in engineering departments large and small.

Complete active drawing files are at the fingertips in just 5% of the space needed for originals. Any drawing—out of thousands—found quickly and viewed clearly in a RECORDAK Film Reader.

This, naturally, reduces the need for reference blueprints, adds up to notable savings in time and printmaking costs. You can also count on savings when you need prints. For with this new system, reduced-scale paper prints can be made directly from your aperture cards by low-cost photographic, xerographic or electrostatic methods. Also, duplicate film cards for branches, vendors, or government agencies can be made for pennies apiece.

Key to successful operation

Outstanding picture quality of Recordak microfilm images (120 lines per mm resolution at 30 to 1 reduction) more than meets DOD requirements.

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Pathon has Something *for Everybody*

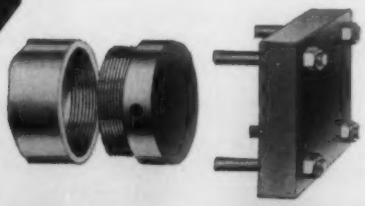
Pathon Cylinders are designed to give you a highly practical cylinder that fits into almost every situation where a hydraulic cylinder is needed. Maintenance is at an absolute minimum because Pathon Cylinders are simple and easier to take apart and put together.

For the Designer

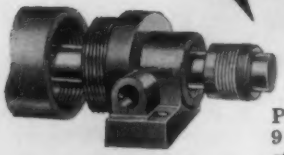
Pathon's compact design saves valuable space, makes your designing job easier, and gives your equipment added dependability with a modern rugged appearance.

For the User

Pathon's screw thread head design gives you up to 40% more strength than most tie-rod cylinders. This increased strength means less maintenance, longer life.



For the Maintenance Man



Rod packing and bearing is externally replaceable and any part can be replaced without complete disassembly and the resulting "basket full of parts."

Pathon Hydraulic Cylinders are available in 9 mounting types, thirteen bore sizes—1⅛", etc., through 14", and three Series—for 1000 PSI, and 2000 PSI and 3000 PSI.

Write for Bulletin No. 22-A

Pathon MANUFACTURING COMPANY

3823 PACIFIC AVE. • CINCINNATI 12, OHIO

FLUID OPERATED AND CONTROL EQUIPMENT

loaded, multiple V-packings that compensate for wear. End cover plates are machined to close tolerances. Step-cut cast iron piston rings are standard. Self-centering floating cushion compensates for high side loads. Cushion needle and ball check are flush-mounted and interchangeable. Concentric lockout design locks piston to rod. O-ring seals throughout cylinder are backed up to prevent extrusion under high shock loads. **Carter Controls Inc, 2992 Bernice Rd, Lansing, Ill.**

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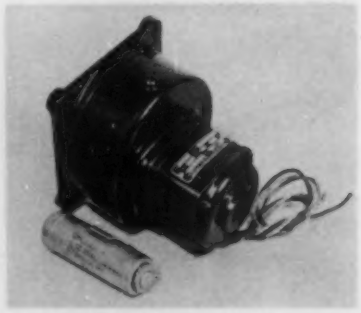

Low-inertia instrument motor provides high starting and running torques and low coast, when deenergized, for remote positioning and control applications. Available with heavy-duty gear reductions from 4:1 to 1800:1. Total space required, less output shaft, is 4⅛ x 4⅛ x 4⅞ in. Typical performance ratings are 750 in.-oz minimum starting torque and 350 in.-oz running torque at 6 rpm and 50% intermittent duty. **Holtzer-Cabot Motor Div, National Pneumatic Co Inc, 125 Amory St, Boston 19.**

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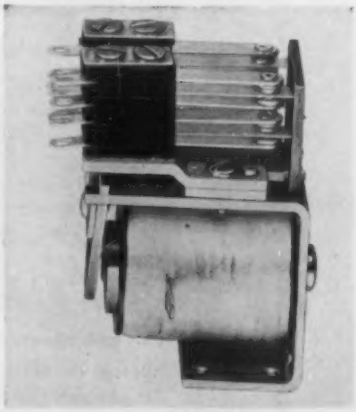
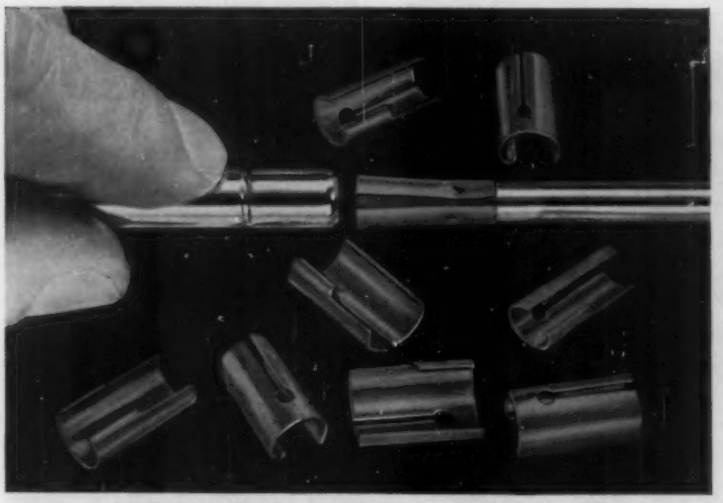


Telephone-type relay . . . with contact arrangements up to 4PDT in voltages from 6 to 220 c ac and dc is

continued on page 252

CREATIVE COST CUTTING

Selecting the metal to fit the job can give you surprising savings in total cost



Small spring clips between telescoping parts of auto radio antennas must maintain electrical contact, hold parts firmly, give smooth sliding action. Brach Manufacturing Division of General Bronze Corp., Newark, N. J., found that spring clips of Duraflex®, Anaconda superfine-grain phosphor bronze, gave best positive electrical contact and improved smooth action in Brach Auto Antennas over original clips made of premium metals. The clips stand up in constant use, spot welding and fabrication are easier—and costs are about 25% lower.

In this G-E Automatic Coffee Maker control, a thermostat turns cam actuating switches—for high heat to brew coffee, for low heat to keep it warm. At first, upper switch element was an assembly of blade, bushing, and locking nut. Tinnerman Products Inc., Cleveland, Ohio, engineered a one-piece Speed Clip to replace it—by forming one thread in the blade and two prongs to lock the screw (see inset above). This simplification called for a superior phosphor bronze. Tinnerman found it in Duraflex, Anaconda superfine-grain phosphor bronze. It has higher tensile strength and endurance limit for long-lasting dependability—greater formability for economical manufacture. The result: unit costs were cut— and G-E assembles controls faster, more easily. 6045

Quality control and cost reduction can go hand in hand. The secret is often simply matching the metal to the job. And Anaconda specialists, starting with 93 standard alloys, can offer an almost unlimited number of combinations of useful properties. For creative help in meeting your problems, write The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA®

COPPER · BRASS · BRONZE

NICKEL SILVER MILL PRODUCTS

Made by The American Brass Company

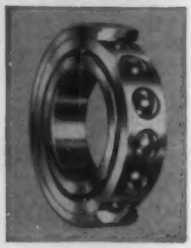
CIRCLE 251 ON READER SERVICE CARD

PRECISION BALL BEARINGS

NEW HDR SERIES

More Bearing in Less Space

Fractured Ring Technique Provides Breakthrough to High Performance



Understandably, selecting a precision ball bearing in which the outer ring has been intentionally fractured is difficult for many engineers long used to thinking in conventional terms of bearing quality. Just as the nameless pioneer who ate the first oyster discovered, despite his probable qualms, that it was extremely palatable and healthful, we hope you'll read on and discover the many advantages of HDR ball bearings.

HDR ball bearings combine the capacity of maximum ball complement bearings with the overall performance characteristics of Conrad-type ball bearings, plus the advantage of a one-piece outer land-riding retainer. This new high performance bearing is made possible by Split Ballbearing's patented fractured ring construction method.

The development of the HDR bearing by Split Ballbearing engineers grew out of the demand for a high performance deep-groove ball bearing, dimensionally interchangeable with standard metric sizes, but with considerably greater capacity and life. General proportions between ball size, ring thickness and raceway shoulders were already well established. The problem was to introduce a greater number of the same size balls between the inner and outer rings without resorting to performance-limiting construction features such as loading slots or counterbored rings.

The construction and assembly of the HDR bearing is the unique solution to the problem. Many hundreds of successful applications of HDR type bearings testify to the sound practicality of their design.

The deep, uninterrupted and symmetrical raceways in both rings of HDR bearings permit relatively high thrust loads in either direction and are ideal for high speed operation. Conrad-type bearings have similar raceway construction, but considerably less load capacity due to their smaller complement of balls.

Balls are placed into loading position. Rings are centered and balls are positioned. Multi-piece retainer is assembled around balls.

Conrad type construction — note how ball complement is limited to about half of available space due to eccentric displacement of rings.

HDR bearings have up to 56% greater load capacity than equivalent size Conrad types. Since bearing life varies inversely as the cube of the applied load, HDR bearings will yield up to 280% greater life, at a given load, than Conrad-type bearings of the same size. How do Split engineers build these high performance bearings? It's relatively simple—look at these diagrams:

1. Inner and outer rings are finish ground to high precision and paired for size. Ball size is selected for desired internal clearance.

2. The scored outer ring is fractured, to permit assembly of a maximum ball complement bearing without loading slots or counterbored rings.

3. Special tools open outer ring sufficiently so it may be snapped over assembly of balls, retainer and inner ring.

4. Banding rings are snapped into O.D. shoulder grooves to prevent opening during handling and installation.

Using maximum ball complements, HDR bearings offer greater rigidity, with an average of 26% less deflection than Conrad-type bearings. Because of their higher radial static capacity, they have an average resistance to shock loads 43% greater than Conrad-type bearings.

A further important advantage of the HDR construction and assembly method is the use of a simple one-piece ball retainer of maximum strength. The retainer is made of bronze, for low friction, and is piloted on the ground shoulders of the outer ring. This piloted, or land-riding construction, keeps the retainer concentric with the bearing rings under all conditions of operation. Because there is more room for retainer material outside the ball circle diameter than inside, the outer land-riding design provides maximum strength. Since the balls do not have to support the weight of the retainer, friction is minimized at the points of high velocity sliding in the ball pockets, thus permitting higher operating speeds.

HDR ball bearings are made in four standard AFBMA series of bearing envelope proportions:

Series 000 extremely light — Series 200 light
Series 100 extra light — Series 300 medium

The present size range is from 10 mm bore through 85 mm O.D. They are available in two grades of precision — ABEC-3 and ABEC-5.

The handling and mounting of HDR bearings is exactly the same as for conventional precision ball bearings.

NEW CATALOG on HDR series

Complete information on Split Ballbearing's new HDR precision ball bearing. Write today for Catalog 60.

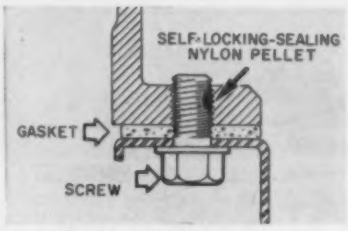
split ballbearing
A DIVISION OF MPB, INC.
906 HIGHWAY FOUR, LEBANON, NEW HAMPSHIRE

medium-duty unit. Coil resistance is 10 k. Priced at $5.50 to $8.05. Delivery, 8 wk. Line Electric Co, 229 River St, Orange, NJ.

Circle 438 on Reader Service Card

Housed thermal timer . . . has two terminals for contact circuit and two terminals for heat circuit. Available with normally open contacts that close after energization or normally closed contacts that open after energization of heater. Timer settings up to 2 min. are offered. Contact rating is 100 w, 115 v ac noninductive load. Stock heater winding is rated at 24 v. Geo Ulanet Co, 413 Market St, Newark 5, NJ.

Circle 439 on Reader Service Card



Self-locking-sealing pellet is permanently imbedded in blind hole tapped in threaded section of screw. Resulting one-piece, self-locking-sealing fastener does not require high sealing load and provides uniform gasket compression. When processed fasteners are threaded into attaching member, compression of protruding pellet creates strong spring-like wedging action that locks and seals mated threads together. This action occurs wherever wrenching stops. Compressed pellet also acts as dam to prevent leakage around helical path of threads. Nylok-Detroit Corp, Troy, Mich.

Circle 440 on Reader Service Card

Precision stepping devices . . . with digital counter or dial readout and variable settings are for monitoring, indicating and/or control functions. Predetermined and remote-setting pulse counters and interval timers operate only on number of pulses received, not incremental changes in voltage or phase angle. Predetermined pulse counters can be supplied with decimal or angle counters and with clutches that allow given setting to be maintained for infinite number of cycles. Other units provide counters that pulse to or from any predetermined setting, perform switching function, then reset to zero

continued on page 253

reference, ready for another operation. In remote-setting interval timers, counters are additive. When last pulse registers, counter resets and opens pulse circuit to perform desired function. **A W Haydon Co, 232 N Elm St, Waterbury, Conn.**

Circle 441 on Reader Service Card

Differential pressure pickup

for extreme environmental conditions is available in 16 differential pressure ranges between 300 and 5000 psia. Transducers operate in −85 to 257 F, with case pressures to 10,000 psia. Proof pressure of each unit is 150% of rated pressure; burst pressure is 200% of rated pressure. Standard resistance value is 7500 ohm ±5%. Units are said to have 1% max linearity error, ½% max friction error, ½% max error through hysteresis effects, 1% max vibration error when subjected to 35-g vibration at 2000 cps. Offers response time of 25 millisec for 63% of applied step. **Servonic Instruments Inc, 640 Terminal Way, Costa Mesa, Calif.**

Circle 442 on Reader Service Card

High-resolution dial assembly

permits movements as small as 10 sec of arc because of ratio of 1350:1. One rotation of vernier knob turns synchro shaft only 16 min. of arc. Intended for panel mounting. Each dial assembly accommodates one synchro size. Rotation is continuous 0 through 360°, clockwise or counterclockwise. Markings on dial are graduated in 1° intervals and on vernier

continued on page 254

Baldor Motor specially-designed for the Southwestern Engineering Co., Los Angeles. This motor, with eccentric weight on both ends of shaft, is the drive mechanism for their efficient SWECO Vibro-Screen Separator.

Another version of same motor designed by Baldor to fit a specific application. Result is a highly efficient power-plant that keeps equipment operating with a minimum of downtime.

Let BALDOR's unique engineering service design the one right motor for your equipment!

To assure maximum efficiency from today's highly complex and precision-built equipment, more than just a standard-type motor is needed to supply the power. It has to be designed and engineered to fit the specific application—not just *adapted* to the equipment.

Baldor's staff of extremely competent engineers has played an important part in helping many original equipment manufacturers develop motors that are "tailor-made" for their particular requirements.

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CIRCLE 253 ON READER SERVICE CARD

TROMBETTA SOLENOID CORP.

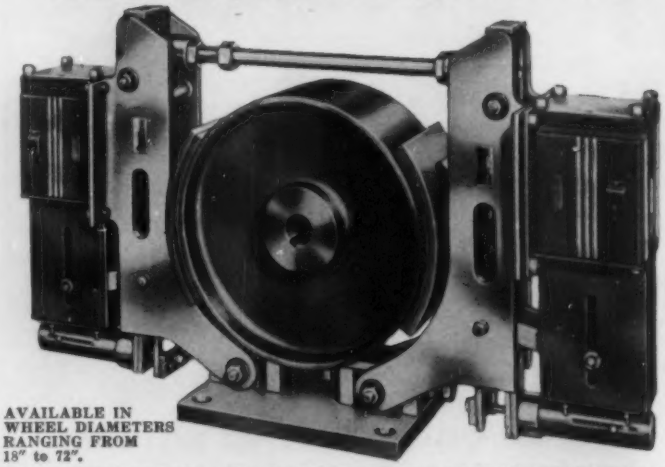
MILWAUKEE WISCONSIN U.S.A

329 N. Milwaukee Street Phone BRoadway 1-8347

NEW DOUBLE-ACTION SOLENOID BRAKES!

from 1,400 ft. lbs. to 75,000 ft. lbs. capacity.

by **TROMBETTA** IN 1924 MR. TROMBETTA GAVE THE WORLD THE COMMERCIAL SOLENOID.



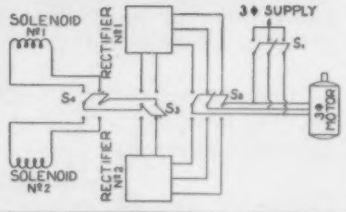
AVAILABLE IN WHEEL DIAMETERS RANGING FROM 18" to 72".

FAST OPERATION—NO MOVING PARTS WHEN BRAKE IS IN OPERATION. Laminated long stroke solenoids used in Trombetta brakes are fast operating, fast releasing. All difficulties resulting from slow operating torque motors and other make-shift operators completely eliminated. When operated on direct current there is nothing moving, and watt consumption is only about 40 watts for biggest brake.

LONGER PERIODS BETWEEN ADJUSTMENTS. Long stroke solenoids use only about 65% of stroke to release brake; other 35% for lining wear. Most durable lining is used—takes longest time to wear. Lining with most constant coefficient of friction gives uniform service.

NO DOWN TIME! NO DOWN TIME!! NO DOWN TIME!!! NO DOWN TIME!!!!
Trombetta Double Action Solenoid Brakes use two solenoids: one operates brake, the other is kept as spare. If one solenoid fails, the spare is put in use instantly. Failing unit can be replaced while brake is in operation.

Trombetta solenoid brakes are operated by either alternating or rectified current. When operated by rectified current, twin rectifiers are used, one to operate solenoid, other as a spare. Selective switches used to change from failing rectifier to good one, again eliminate down time.



Trombetta Theta line of brakes ranging from 3 ft. lbs. to 75,000 ft. lbs. are for alternating current, direct current (series or shunt); hydraulic or air operation.

Trombetta also manufactures solenoids for all requirements, and Reciprometors and Semotors. Write for Bulletin EE 222.

"TROMBETTA"

is the answer to all questions pertaining to:
SOLENOIDS, SOLENOID OPERATED BRAKES, RECIPROMOTORS, AND SEMOTORS

dial in 0.1° intervals. Accuracy is said to be 0.1°; readability, 0.1°. Price is $170. Delivery, 4 wk. Theta Instrument Corp, 520 Victor St, Saddle Brook, NJ.

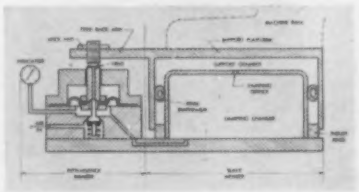
Circle 443 on Reader Service Card

Precision instrument switch . . . has total resistance of 0.7 milliohm, which remains constant to ±20 microohm. Primarily intended for use on instruments for measuring of electrical potential and resistance. Settings for switch are located by click mechanism consisting of two ball-bearings pressed against moving end plate by parallel leaf springs. Totally enclosed unit is lubricated before leaving factory. Ealing Corp, 40 University Rd, Cambridge 38, Mass.

Circle 444 on Reader Service Card

Subminiature servovalves . . . weigh 5.12 oz. Electrohydraulic valve has nozzle-flapper hydraulic amplifier and mechanical feedback arrangement. Uses small second-stage spool and bushing contained in lightweight aluminum body. Max flow capacity is 3 gpm at 3000 psi. Moog Servocontrols Inc, East Aurora, NY.

Circle 445 on Reader Service Card

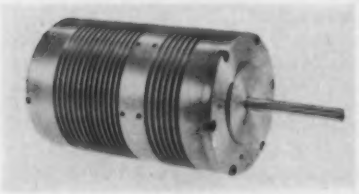


Mount maintains absolute level within 0.0005 in. per ft of length, regardless of load, with repeatable accuracy said to be better than ⅛ of 1%. Machinery mount is basically a pneumatic servomechanism—installed by sliding it under support points of equipment. Leveling is accomplished by Allen-wrench adjustment.

continued on page 255

Operating from standard factory air supply, mount automatically compensates for changes in loading, variations in floor level due to changes in foundation rigidity, external and internal thermal changes. At the same time, mount is reported to isolate vibration and shock. **Barry Controls, 700 Pleasant St, Watertown, Mass.**

Circle 446 on Reader Service Card



Variable-speed synchronous motor . . .

for extreme slow speeds was originally designed to drive spindle in automated machine tool. Two identical counter-rotating motors are in housing. One motor is connected to 60-cps line; the other to a variable-frequency power supply. If variable frequency is 60 cps, output shaft is stationary and opposes rotation with full motor torque. Increase or decrease of variable frequency begins to turn shaft forward or reverse. If 60.6 cps are applied, shaft speed is 18 rpm. At 66 cps, shaft rpm is 180. Motors can be built from 1/50 to 1 hp. **Bekey Electric Div, Genisco Inc, 2233 Federal Ave, Los Angeles 64.**

Circle 447 on Reader Service Card

Lightweight pressure switches

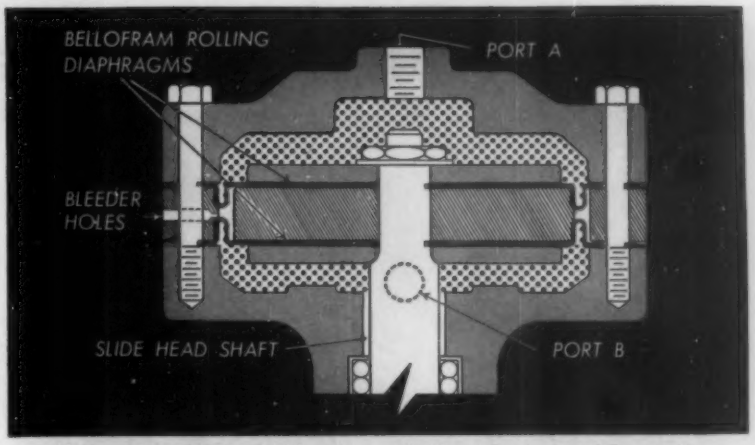
measures 1⅞ in. dia and 2½ in. long. Weigh 2 oz. Available for operation at any fixed pressure between 5 and 1000 psi. For use in fuel, hydraulic, pneumatic or refrigeration applications in temperatures of −65 to 275 F. Said to meet environmental and vibration requirements of MIL-E-5272A and to withstand shocks to 100 g. Contact ratings at 30 v dc are 2½ amp inductive or 5 amp resistive at 50,000 ft; at 125 or 250 v ac, 5 amp. **Consolidated Controls Corp, Sub Consolidated Diesel Electric Corp, Bethel, Conn.**

Circle 448 on Reader Service Card

Lightweight pressure pickups . . .

are reported to have temperature stability of 0.01% per F through range of −65 to 350 F. Sensing element is precision Ni-Span-C bourdon tube. Vibration tolerance is 1% max change for 10 g to 2000 cps; acceleration is 1% max shift at 50 g. For shock, units are said to meet MIL-E-005272-B specifications. Power rating is

continued on page 256



Air pressure entering double-acting cylinder at Ports *A* and *B* actuates slide head shaft, which controls positioning of upper electrode. Sensitive low inertia response is achieved by two frictionless Bellofram Rolling Diaphragms. Bleeder holes maintain a pressure differential.

Frictionless Rolling Diaphragms Insure Fast Follow-up for Welder

PROBLEM: To design, for use in an automatic welding machine, a pneumatic actuator for positioning the upper electrode in response to expansion or contraction of the weld nugget. Sensitive, frictionless movement was mandatory to provide instantaneous reaction to momentary changes in nugget dimensions.

SOLUTION: Federal Machine & Welder Company's designers specified a double-acting air cylinder with two Bellofram Rolling Diaphragms, each molded from a dacron fabric impregnated with a nitrile elastomer.

With no mechanical spring gradient, no break-out friction effects, and low hysteresis, these rolling, non-porous membranes instantly translate pressure changes into movement of the electrode control head. Although very sensitive to pressure variations, they are capable of sustaining high working pressures, because the force experienced on the narrow convolution is only a small fraction of the total force applied over the effective pressure area.

Operating between wide temperature ranges, these Bellofram Rolling Diaphragms provide a flex life of millions of cycles, yet do not require lubrication or close machine fits for piston and cylinder.

Bellofram Rolling Diaphragms are free positioning and friction-free. They roll off the piston sidewall and onto the cylinder sidewall in a smooth, continuous motion.

WHAT IS YOUR PROBLEM?

If conventional bellows, O-rings, cup packings, etc., fall short of your requirements, Bellofram Rolling Diaphragms may be the answer. Special types can be designed for use with almost any gas or fluid in actuators, pumps, instruments, seals, accumulators, fluid dampers, etc.

OPERATING LIMITS

Operating Pressures: 1 inch H_2O to 500 psi (up to 1200 psi in some cases).

Operating Temperatures: −85°F. to +550°F. (from −120°F. to +700°F. in some cases).

Cylinder Bore Sizes: .25 to 12 inches.

Effective Pressure Area: .028 to 108 square inches.

Total Stroke Capabilities: .01 to 12 inches.

Sidewall Thickness: .008 to .035 inches.

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- Complete range of sizes

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2984 Bernice Road, Lansing, Ill.
Phones: Lansing—Glenville 4-3300 • Chicago—Skyport 1-7188

0.7 w at 70 F. Pressure range of the seven models varies from 0-100 to 0-5000 psig. Pancake-shaped units, ⅞ x 1¾ in., each weigh 3.5 oz. Quantity unit price is approximately $175, with 4-wk delivery. International Resistance Co, 401 N Broad St, Philadelphia 8.

Circle 449 on Reader Service Card

Servomotor-damping generator . . .

is size-8, 400-cps unit consisting of modified, low-torque servomotor and high-output, low inertia generator. Low null voltage combined with high generator output result in 100:1 signal-to-noise ratio. Has phase shift of 0° and linearity of 0.2%. Power input for motor is 2.3 w; for generator, 1.3 w. Kearfott Div, General Precision Inc, 1150 McBride Ave, Little Falls, NJ.

Circle 450 on Reader Service Card

162 pushbutton switches . . .

are now available in three different styles: with direct-actuating leaf spring mechanism in 2, 3 or 4 SPDT basic snap-action switches; assemblies with external positive-acting pushbutton actuators with from 2 to 6 pole, DT circuitry; alternate-action pushbutton switches with DPDT circuitry in which each actuation of switch reverses position of contacts. All are available in black, red or white button colors. Electrical rating is 5 amp, resistive; 3 amp inductive. Basic snap-action, subminiature switch is reported to meet MIL-S-6743 and MS-25085. Haydon Switch Inc, Waterbury 20, Conn.

Circle 451 on Reader Service Card

Transistor time-delay relay . . .

for applications where delay switching and high current are required operates on 18 to 32 v dc with control voltage of 28 v dc, positive. Over-all accuracy is said to be 2%. Withstands shock of 100 g ±5, one-half sine wave, 2 to 10 millisec duration and vibration of 10 g, from 5 to 2000 cps. Time delay can be adjusted over range of 10% above and below nominal. About 8 cu in. in size. Operates in —65 to 125 F. Weighs 8 oz max. Sloan Co, 7704 San Fernando Rd, Sun Valley, Calif.

Circle 452 on Reader Service Card

DESIGN LITERATURE

Plastics Engineering Handbook

Society of the Plastics Industry Inc. Reinhold Publishing Corp, 430 Park Ave, New York 22. 11 x 8, 565 pp. $15.

This is the 3rd edition of a clearly written reference on plastics materials, methods and fabrication, now revised, expanded and up to date. This new edition adds the advances made since 1954; advances so numerous that the handbook now appears in a larger, double-column format. There is new material on nomenclature, cellular plastics, decorating, welding, and plastics as adhesives. The text is illustrated with photographs, tables and charts.

Physics for Students of Science and Engineering

ROBERT RESNICK and DAVID HALLIDAY. John Wiley & Sons, Inc, 440 Fourth Ave, New York 16. 6 x 9½, 554 pp. $6.

This book, in two volumes, attempts to meet the most frequent criticisms made of physics textbooks. It has tried to treat topics with sufficient depth; make the contents sufficiently "modern" with applications drawn from contemporary physics; to organize material to reveal the essential unity of physics and its principles; and to stress the connection between theory and experiment. Part I deals with mechanics, wave motion and heat; Part II is concerned with electromagnetism, optics and quantum physics.

Both parts are well illustrated and the editorial styling that has gone into the two volumes make them extremely clear and stimulating. They should supply a long-felt need.

Creep Behavior of Structural Joints

MORDFIN, HALSEY, GREENE. Technical note D-181. National Bureau of Standards, National Aeronautics and Space Administration, 1520 H St NW, Washington 25, DC. 8 x 10½, 37 pp. $1.

Full title: "Investigations Of Creep Behavior of Structural Joints Under Cyclic Loads and Temperatures."

Eighty-two structural joint specimens were tested to evaluate the effects of cyclic loads and cyclic temperatures on creep and rupture. The specimens included riveted joints of 2024-T3 clad-aluminum alloy, and riveted and spot-welded joints of 17-7 PH (TH 1050) stainless steel. The results of these tests show a wide variance, but indicate certain trends which permit the estimation of the cyclic creep behavior of joints.

An analysis of the effects of stress concentration on the tensile rupture strength of riveted joints is also presented. This, together with data from several other laboratories, shows that the effects are small for joints fabricated from notch-ductile materials and conventional rivets.

Molten Salts

BENSON R SUNDHEIM. New York Academy of Sciences, 2 East 63rd St, New York 21. Vol. 79, Art 11. 6 x 9, 337 pp. $5.

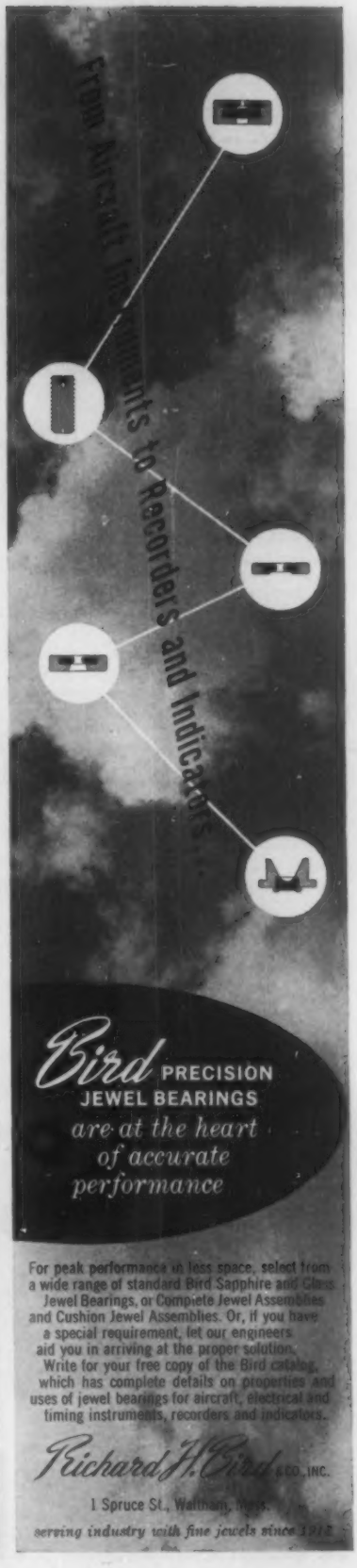
In such new power sources as fuel cells and nuclear reactors, as well as in such old, established processes as heat-treatment, molten salts play important roles. This volume, a compilation of talks presented at a NYAS symposium last year, rounds up recent research developments. It is highly technical, and many of the individual chapters are limited in scope. But, taken together, they are a valuable library addition if only because they show who is studying molten salts, and indicate the direction of their research program.

Qualitative Aspects of Fatigue of Materials

HAROLD N CUMMINGS, Curtiss-Wright Corp, Propeller Div. PB-161145 (WADC Technical Report 59-230). Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 250 pp. $4.

This book is a useful one-volume source book on fatigue, particularly when all that the reader is seeking is a concise summary of current thinking on some aspect of the problem. Drawn from some 300-odd references, listed in the appendix, the book is written for the nonspecialist and includes the following chapters: Relation of fatigue properties to other physical properties, statistical nature of fatigue strength and life, variability in fatigue strength and life, factors affecting fatigue-test results, effect of stress raisers, notch-strength reduction factors and sensitivity, effect of metallurgical treatment, effect of mechanical treatment,

continued on page 259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effect of environmental conditions, effect of damping on fatigue, acoustic fatigue, and mechanism of fatigue.

Malleable-iron Castings

Malleable Founders Society, Union Commerce Bldg, Cleveland 14. 9½ x 6, 526 pp. $10.

A complete reference with new data on properties of the standard ferritic malleable irons as well as the pearlitic and alloyed grades. The data, from research programs sponsored by the industry, includes values for fatigue, impact and stress rupture at elevated temperatures from 800 to 1200 F. It also contains useful information on how to design for malleable. Unfortunately, its high price might not be justified because the book is limited to this specific family of materials.

Electromagnetic Fields, Energy, and Forces

FANO, CHU, ADLER. John Wiley & Sons Inc, 440 Park Ave S, New York 16. 6 x 9, 520 pp. $12.

Here is a consistent macroscopic theory of electromagnetism, discussing the relationship between circuit theory and field theory. The theory is developed in successive steps from the Lorentz force, the integral form of Maxwell's equations in free space, and suitable macroscopic models of polarized and magnetized matter. Covered are: electromagnetism of moving

continued on page 260

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Here's a complete ½" In-Line Valve with a 7.5 C_v! Springless (pneumatic or hydraulic), spring-to-open or spring-to-close operation. The operating method can be changed easily in the field without extra parts.

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bodies and the process of electromechanical-energy conversion; power-series technique for analyzing quasi-static fields and quasi-stationary systems; synthesis of fields as opposed to the analysis of fields; four-dimensional relativistic formulation of macroscopic electrodynamics recently developed by one of the authors (L J Chu).

Loads and Deformations of Buckled Rectangular Plates

MANUEL STEIN, (Technical Report R-40), Langley Research Center, Langley Field, Va, National Aeronautics & Space Administration, 1520 H St NW, Washington 25, DC, 8 x 10½, 71 pp, $1.

The nonlinear, large-deflection equations of von Karman for plates are converted into a set of linear equations by expanding the displacements into a power series in terms of an arbitrary parameter. The post-buckling behavior of simply supported rectangular plates subjected to longitudinal compression and to a uniform temperature rise is investigated in detail by solving the first few of the equations.

Experimental data are presented for the compression problem. Comparisons, made for total shortening and local strains and deflections, indicate good agreement between experimental and theoretical results.

Acrylic Resins

MILTON B HORN. Reinhold Publishing Corp, 430 Park Ave, New York, 22, NY. 8½ x 6, 184 pp. $4.50.

Describes the four types of acrylics in respect to their manufacture, fabrication and applications. These types include cast products, molding compounds, emulsion and solution compounds. The author explains raw materials and manufacture of these polymers sufficiently for an understanding of the problems involved in fabrication and application. Then he covers the current and future developments in terms of potential use in a great variety of products. All material presented in the book is available in the literature.

Other Books of Interest

Trimmer Potentiometers

Orlin Watley. Dale Products Inc, Box 135, Columbus, Neb. 5½ x 8½, 21 pp. 50¢.

Resistors

Bernard Hay. Dale Products Inc, Box 135, Columbus, Neb. 5½ x 8½, 31 pp. 50¢.

Development of an Operational Preservative Hydraulic Brake Fluid

PB 161096. C B Jordan. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 18 pp. 75¢.

American Standards Class 5 Interference Fit Threads

ASA B1.12. American Society of Mechanical Engineers, 29 W 39 St, NY 18. 8½ x 11, 12 pp. $1.

1960 US Aircraft, Missiles & Spacecraft

Aerospace Industries Assn, 610 Shoreham Bldg, Washington 5 DC. 8½ x 11, 153 pp. $1.

All currently operative models pictured and described.

Techniques & Drafting Aids

Alvin & Co, Inc, 611 Palisado Ave, Windsor, Conn. 8½ x 11, 32 pp. 50¢.

Science Study Series

This series is intended as an aid in the teaching and study of physics. Written in an easy-to-read, popular style, the series includes so

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far: "Crystals and Crystal Growing," "Waves and the Ear," "How Old Is the Earth?" "Soap Bubbles and the Forces Which Mold Them," "The Birth of a New Physics," "Echoes of Bats and Men". Priced at 95¢ each, they are available from the publisher, Doubleday & Co Inc, 575 Madison Ave, New York 22. Previously reviewed: "The Neutron Story," "Magnets."

Rotating Air Cylinders and Adapters

ASA B5.5-1959. American Standards Assn, 70 E 45th St, New York 17. 8½ x 11, 6 pp. $1.

One of a series of standards for small tools and machine-tool elements.

Research on Elevated Temperature-resistant Inorganic Polymer structural Adhesives

PB 131934. Harold H Levine. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 52 pp. $1.50.

Research Highlights of the National Bureau of Standards, 1959

Misc Pub 229. Superintendent of Documents, US Government Printing Office, Washington 25, DC. 5¾ x 9, 169 pp. 55¢.

Describes scientific studies, laboratory experiments, and instrumentation developments.

1960 European Technical & Commercial Trade Fairs

European Technical Coverage Inc, 75 E Wacker Drive, Chicago 1. 8¼ x 12½, 12 pp. $5.

A comprehensive guide listing more than 500 major European technical and commercial trade fairs scheduled in 1960.

Surface Effects on Spacecraft Materials (first symposium)

F J Clauss. John Wiley & Sons Inc, 440 Fourth Ave, NY 16. 9 x 11¼, 404 pp. $11.50.

Machine-shop Estimating

W A Nordhoff. McGraw-Hill Book Co Inc, 330 W 42 St, NY 36. 6¼ x 9¼, 528 pp. $9.

Work Improvement

G C Close, Jr. John Wiley & Sons Inc, 440 Fourth Ave, NY 16. 6 x 9¼, 388 pp. $7.75.

Mechanical Properties of Intermetallic Compounds

J H Westbrook. John Wiley & Sons Inc, 440 Fourth Ave, NY 16. 6 x 9¼, 435 pp. $9.50.

Physics in Your Highschool

McGraw-Hill Book Co Inc, 330 W 42 St, NY 36. 5½ x 8, 134 pp. $1.50.

Proceedings of the First National Symposium on Nondestructive Testing of Aircraft and Missile Components

Southwest Research Institute, 8500 Culebra Road, San Antonio, Tex. 6¼ x 9¼, approx. 300 pp. $10.

Abstracts and bibliographies also available from SRI.

continued on page 262

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CIRCLE 261 ON READER SERVICE CARD

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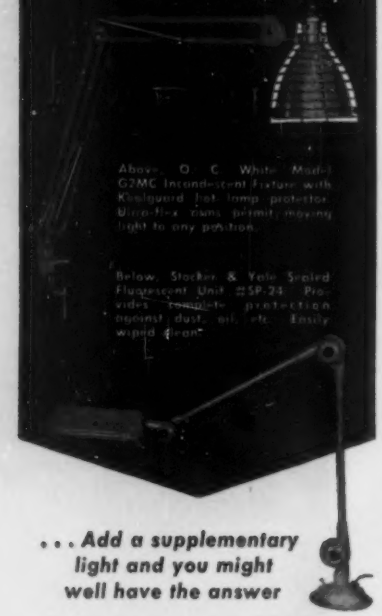
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Conference on Research in Progress on Tungsten

PB 161013. Office of Technical Services, Dept of Commerce, Washington 25, DC. 124 pp. $2.50.

Recommendations for the Dimensions and Output Ratings of Electric Motors, Part I

IEC No. 72-2. American Standards Association, 70 E 45th St, New York 17. $2.40.

Recommendations cover foot-mounted induction motors with shaft heights between 56 and 315 mm (2⅛ and 12½ in.).

Imagination at Work

16-mm film. Roundtable Productions, 139 S Beverly Dr, Beverly Hills, Calif. B & W—$120; color—$240.

Film (22 min. running time) available for purchase or rental ($25 per wk). Purpose is to stimulate flow of new ideas and to aid in developing an atmosphere in which creative abilities are encouraged.

The Engineering of Agreement

16-mm film. Roundtable Productions, 139 S Beverly Dr, Beverly Hills, Calif. B & W—$140; color—$240.

Film (18 min. running time) available for purchase or rental ($25 per week). Demonstrates psychologically proven techniques which are of great value in obtaining agreement. It is applicable to any idea, product or service.

Person-to-Person Communication

16-mm film. Roundtable Productions, 139 S Beverly Dr, Beverly Hills, Calif. B & W—$100; color—$200.

Film (14 min. running time) available for purchase or rental ($25 per wk). Analyzes the major barriers to interpersonal understanding, and points out, as well as demonstrates, specific, practical methods for overcoming these barriers. Designed for use by training directors, supervisors and executives who are interested in improving communications skills.

ABSTRACTS FROM THE LITERATURE

Reinforced Plastics

This paper is a progress report of North American Aviation's endeavor to determine the suitability of fiberglass reinforced plastics in thermoacoustic environments.

"The Suitability of Some Fiberglass Reinforced Plastics in Thermoacoustic Environments," J. M. Baskin Sr, Dyn. Eng'r, North American Aviation Inc. Proceedings of the Institute of Environmental Sciences, Box 191, Mt Prospect, Ill.

Bourdon Tubes

Bourdon tubes deflect in two ways, first due to internal pressure, and second as a curved beam due to external load. This article treats deflection of the bourdon tube with external

continued on page 263

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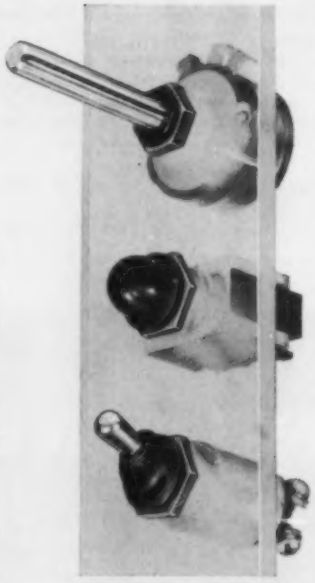

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load. Final results can only be obtained by experimentation. But results given here permit analysis of the action and make the design of bourdon tube instruments semianalytical.

"Bourdon Tubes Designed as Curved Beams," G. Kardos, Aviation Electric Ltd, Montreal, Quebec. Design Engineering, April '60, 481 University Ave, Toronto, Canada.

Corrugated-sandwich Structures

This paper describes the development of forming and joining techniques for corrugated-sandwich structure. Techniques developed include rolling, manual and automatic fusion welding, resistance spot welding, and tungsten-arc spot welding. Evaluation of welding methods is based on results of tensile-shear tests and metallographic examinations. Applicability of the techniques developed to other types of corrugated sandwich-structure assemblies is considered.

"Development of Forming and Joining Techniques for Corrugated-sandwich Structure," H. Smallen and R. P. Romaine, Materials Research Laboratory, Norair Div, Northrop Corp, Hawthorne, California. Welding Journal, April 1960, 20th and Northampton Streets, Easton, Penna.

Biomagnetics

Proposals that space vehicles be propelled by means of ion accelerators, fusion reactors, photon motors, and other teratogenic devices often involve the potential use of strong magnetic fields. Experimental evidence suggests that magnetic fields produce a variety of effects upon living matter; however, these facts are not well publicized. In this paper some of the findings of

continued on page 265

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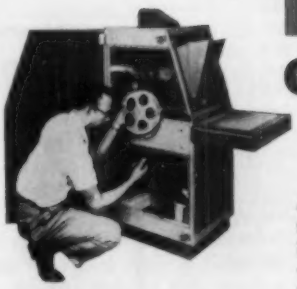

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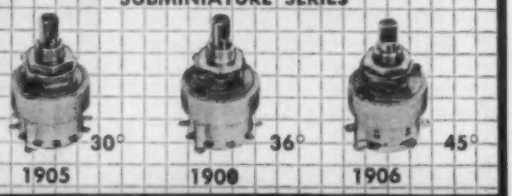

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published studies are summarized with the intent of stimulating interest in the domain of biomagnetics, and the need for caution is pointed out when humans are subjected to the influence of powerful magnetic fields.

"Biomagnetics," Harold S. Alexander, Human Factors Engineering Missile Division, North American Aviation, Inc. Proceedings of the Institute of Environmental Sciences, Box 191, Mt Prospect, Ill.

Ultraviolet vs Structural Plastics

Space vehicles and their component materials at extreme altitudes will be exposed to environments of greatly reduced pressure and intense solar radiation. Experimental studies were conducted on the effects of combined environments of heat, low pressure and ultraviolet radiation on the change in weight and flexural strengths of glass reinforced polyester, epoxy and phenolic laminates. All plastics lost weight; some gained in strength and others lost 25-30% in flexural strengths.

"Influence of Ultraviolet and Vacuum Environments on Structural Plastics," Harold M. Preston and Norman E. Wahl, Cornell Aeronautical Laboratory Inc, Buffalo 21, NY. Proceedings of the Institute of Environmental Sciences, Box 191, Mt Prospect, Ill.

Structural Design of Plastics

In the first part of this article, the mechanical properties of plastics of particular interest to the designer of structural parts are discussed. Included are analyses of such factors as the stress-strain curve; effect of temperature and loading time and environment; yield point; tension, compression and flexure. In the second

continued on page 267

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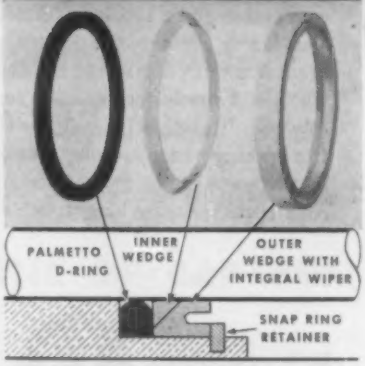

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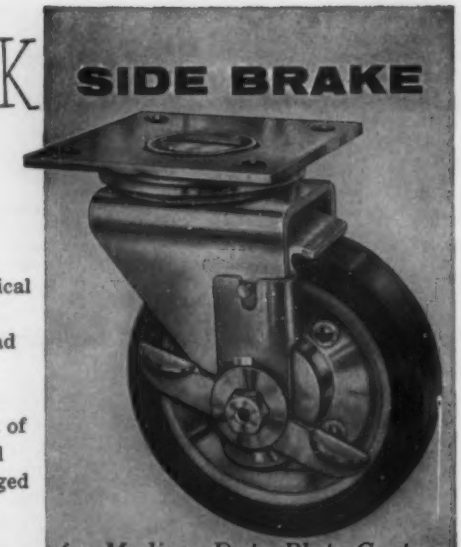

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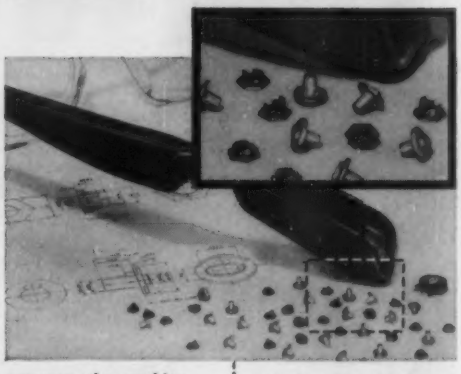

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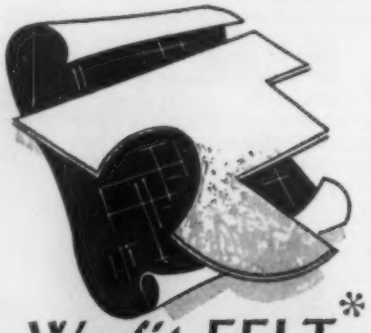

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part, devoted to design methods, means of applying the mechanical properties and concepts presented earlier are described and illustrated. Typical formulas for designing within the modulus accuracy limit are given, as well as curves on such factors as beam deflection and max load capacity.

"Structural Design of Plastics," Baer, Knox et al, E I du Pont de Nemours & Co. SPE Journal, April '60, 65 Prospect St, Stamford, Conn.

Bolt Bending Stresses

Although screws and bolts are designed chiefly for axial loads, they are often subjected to bending or shearing stresses. Where this occurs, the design must include some means of overcoming these stresses.

There are four basic solutions for this problem: Dowel pins, dowel bolts, bushings, intermeshing component shapes. These solutions are examined.

"Bolt Bending Stresses," Federico Strasser, Santiago, Chile. Design Engineering, April '60, 481 University Ave, Toronto, Canada.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

SOLID-STATE CONVERSIONS – Brochure, about 22 pp. Presents advancements on new systems and components, particularly in size reduction and extended environmental range as made possible by use of solid-state techniques. Diaphlex Div, Cook Electric Co, 2700 Southport Ave, Chicago 14.

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ECONOMIC CONSIDERATIONS IN BUYING AND SELLING – Booklet GET-3029, 36 pp. Starting from the premise that a sale and a purchase are just two aspects of the same transaction, publication suggests ways in which buyers and sellers can work more closely to their mutual advantage. Author D K Blake discusses value, price-volume-cost relations and other topics. General Electric Co, Schenectady 5.

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continued on page 269

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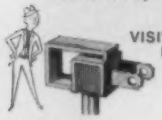

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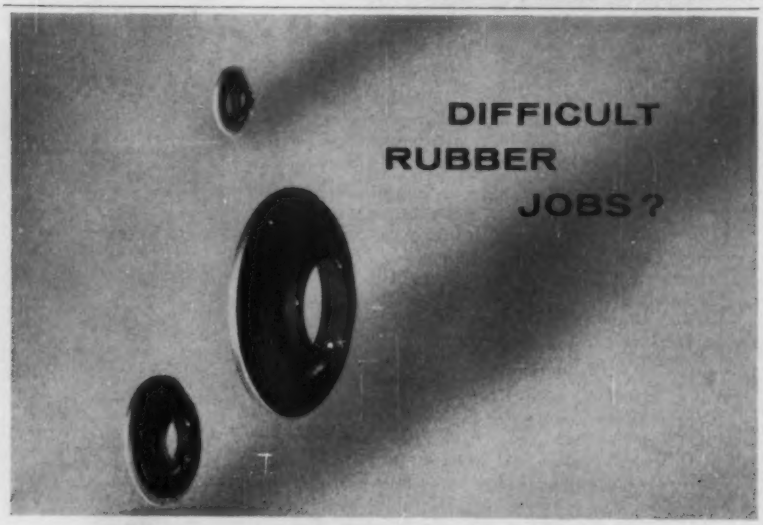

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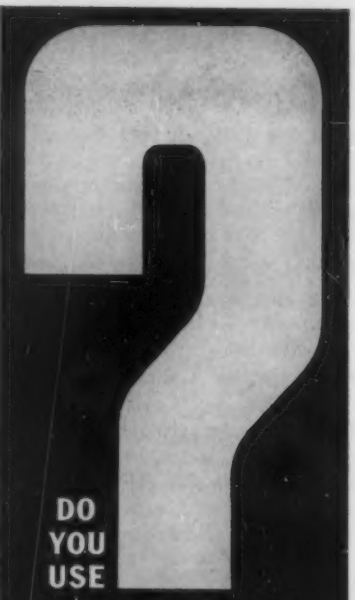

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REUSABLE HYDRAULIC COUPLINGS, HOSE, FITTINGS – Catalog D-1, 24 pp. Product information on hydraulic couplings, hose, adapters, grease-hose assemblies and hydraulic-hose assemblies of all types. Also includes application data, specifications, engineering recommendations and methods of computing length of hose assemblies. Anchor Coupling Co Inc, Libertyville, Ill.

Circle 68 on Reader Service Card

BEARING BRONZES–Brochure, 16 pp. Describes bearing bronzes, and gives specifications, chemical composition and mechanical properties of brass and bronze casting alloys and manganese and aluminum bronze alloys. Includes design information on bearings, bushings, bar stock and babbitt metal. American Crucible Products Co, 1317 Oberlin Ave, Lorain, Ohio.

Circle 69 on Reader Service Card

EXTRUDED STAINLESS SHAPES – Booklet, 16 pp. Contains photos of 38 shapes, a guide to design considerations, standard tolerances and specifications on wide range of metals regularly extruded, glossary of extruded-shape terms and schematic drawings describing some unusual aspects of extruding steel and stainless steel. H M Harper Co, 8200 Lehigh Ave, Morton Grove, Ill.

Circle 70 on Reader Service Card

WINDING PRINCIPLES – Handbook, about 18 pp. Extensively revised since publication of the first edition in 1958, brochure describes general principles of center-shaft winding of sheet materials and provides formulas and other data for calculating torque, speed, tension requirements. Winding machines and accessories are illustrated. Hobbs Mfg Co, 26 Salisbury St, Worcester 5, Mass.

Circle 71 on Reader Service Card

continued on page 271

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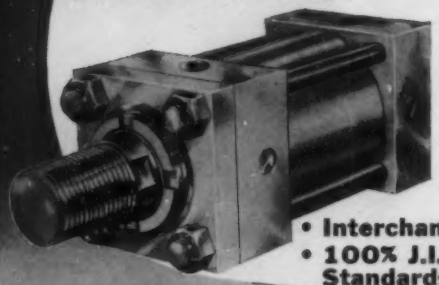

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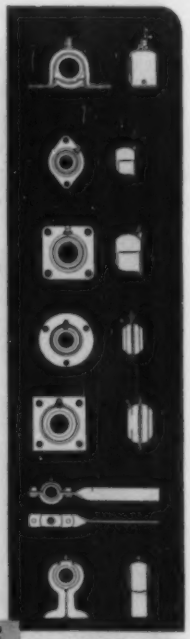

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CIRCLE 484 ON READER SERVICE CARD

INDUSTRIAL AMPLISTATS AND AMPLISTAT REACTORS – Bulletin GEA-6930, 20 pp. Contains tables of statistical data by model number, descriptions of products, typical applications, and presents wiring diagrams and selection guide. Lists proposed magnetic-amplifier standard definitions. General Electric Co, Schenectady 5.

Circle 72 on Reader Service Card

POTENTIOMETERS–Brochure, 20 pp. Covers applications, mechanical operation, nonlinears, design information and abbreviated specifications of ac precision potentiometers and related components. Vernistat Div, Perkin-Elmer Corp, Norwalk, Conn.

Circle 73 on Reader Service Card

SNAP-LOCK LIMIT SWITCH – Bulletin EC-SL260, 16 pp. Covers key design features of SL-2 switch, operation, switch specifications, parts and ordering information. Electrical Controls Div, National Acme Co, 170 E 131st St, Cleveland 8.

Circle 74 on Reader Service Card

ESSENTIALS OF GEAR SHAVING–Manual 5-60-1B, 16 pp. Presents information on basic gear production and gear shaving. Both line drawings and photographs are used to illustrate principles and considerations. Application table is included. National Broach and Machine Co, 5600 St Jean Ave, Detroit 13.

Circle 75 on Reader Service Card

UNIONS AND VALVES–Catalog 60, 16 pp. Revised edition contains specifications, ratings, sizes, weights and dimensions on gasketless cup-orifice unions and ductile-iron check valves. Catawissa Valve & Fittings Co, Catawissa, Penna.

Circle 76 on Reader Service Card

continued on page 273

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PHOTOVOLTAIC CELLS – Bulletin GEZ-3005, 8 pp. Offers description of sensors for use where light performs control function. Includes dimensions and typical circuits for single and multiple-cell applications. General Electric Co, Schenectady 5.

Circle 77 on Reader Service Card

NONFERROUS ALLOYS–Bulletin 157, 8 pp. Chart shows comparative specifications, chemical analyses and min physical properties of nonferrous alloys. Also describes component parts and assemblies produced by centrifugal method. Centrifugally Cast Products Div, Shenango Furnace Co, Dover, Ohio.

Circle 78 on Reader Service Card

FORMICA MOLDED PRODUCTS – Booklet, 8 pp. Outlines molded products service and describes molded products for range of industrial applications. Properties of 25 laminates available in molding grades are listed. Formica Corp, 4614 Spring Grove Ave, Cincinnati 32, Ohio.

Circle 79 on Reader Service Card

GAS-TURBINE POWER–Bulletin GEA-7083, 8 pp. Describes line of 75 to 20,000-hp gas turbines. Gives performance and operating characteristics, applications. General Electric Co, Schenectady 5.

Circle 80 on Reader Service Card

RESISTANCE-ALLOY WIRE – Data sheet, 2 pp. Performance characteristics, descriptions and tables showing diameters are included for resistance-alloy wire with dual-layer, high-temperature insulation. Kanthal Corp, Amelia Pl, Stamford, Conn.

Circle 81 on Reader Service Card

NATURAL QUARTZ - CRYSTAL TRANSDUCERS–Bulletin 101160, 4 pp. Describes range, sensitivity and construction of natural quartz-crystal transducers for pressure, force, acceleration and vibration measurements. Kistler Instrument Corp, 15 Webster St, N Tonawanda, NY.

Circle 82 on Reader Service Card

SUBMINIATURE LATCHING RELAY –Interim bulletin BR-2, 2 pp. Describes magnetic latching relay with 10-amp contacts, which operates on 100 milliw min. Babcock Relays Inc, 1640 Monrovia Ave, Costa Mesa, Calif.

Circle 83 on Reader Service Card

QUALITY CONTROL FOR PRINTED WIRING–Bulletin P-10, 4 pp. Covers quality-control procedures in accordance with MIL-Q-9858 and MIL-STD-105. Photocircuits Corp, Dept 1700, 31 Sea Cliff Ave, Glen Cove, NY.

Circle 84 on Reader Service Card

continued on page 275

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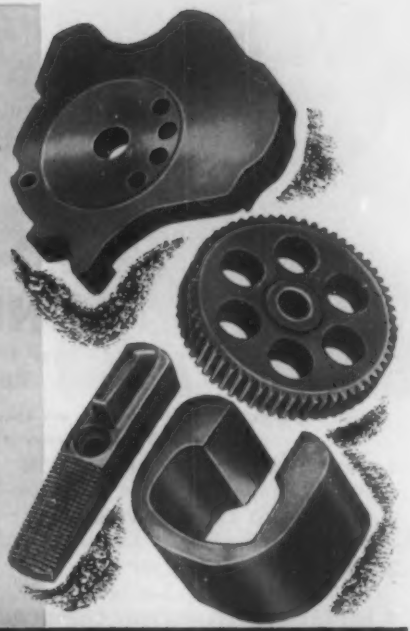

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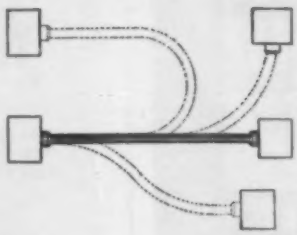

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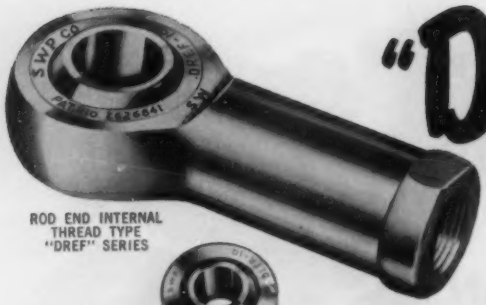

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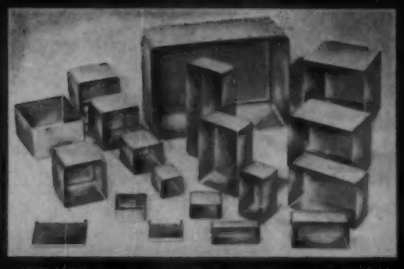

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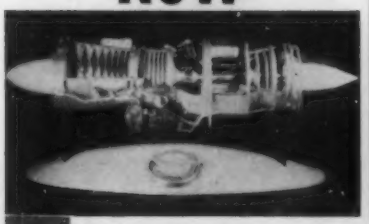

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DESIGN LITERATURE.....continued

ALL-STAINLESS FILTERS – Bulletin M-213A, 4 pp. Lists stock and nonstock stainless steel filter and filter elements. Methods of specifying filter area requirements are shown, with special emphasis on flow rates and porosity grades. Micro Metallic Div, Pall Corp, Glen Cove, NY.
Circle 85 on Reader Service Card

CONSTANT-TEMPERATURE BLOCK –Bulletin 778, 2 pp. Gives performance features, applications and specifications of device for maintaining laboratory samples at predetermined temperature. Beckman Scientific and Process Instruments Div, Beckman Instruments Inc, Fullerton, Calif.
Circle 86 on Reader Service Card

METAL SPECIALTY PRODUCTS – Bulletin 300-P10, 4 pp. Lists line of metal specialty products and production facilities of company. Commercial Shearing & Stamping Co, Youngstown 1, Ohio.
Circle 87 on Reader Service Card

POLYVARIABLE EXPERIMENTATION–Brochure, 4 pp. Describes newly developed methods for experimentation with 10, 20 or more variables. Also discusses available training programs and literature. Statistical Engineering Institute, 8 Fuller Rd, Wellesley, Mass.
Circle 88 on Reader Service Card

PORTABLE LABORATORY RECORDER–Bulletin 774, 2 pp. Lists operating features and performance specifications of strip-chart recorder for laboratory use. Beckman Scientific and Process Instruments Div, Beckman Instruments Inc, Fullerton, Calif.
Circle 89 on Reader Service Card

continued on page 277

"Let's call it a 'Bill of Materials' instead of a 'Do-it-yourself List'".

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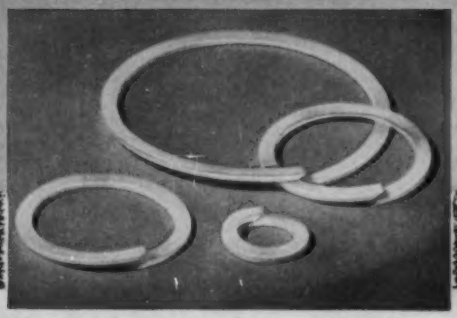

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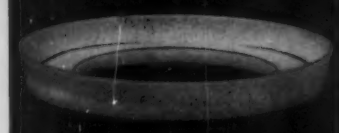

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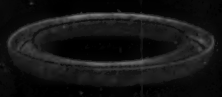
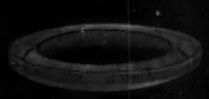


Style 614 V Rings



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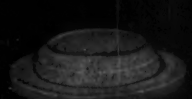

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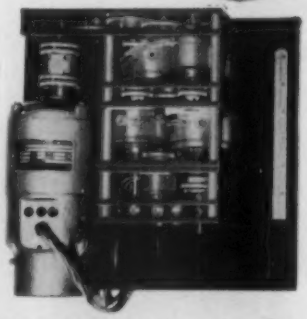

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SCIENCE: Exciting, Incomplete

JOHN R. PLATT

Physics professor, Univ of Chicago
(From a talk at a Thomas Alva Edison science symposium.)

What I want to pick out and discuss here are particular qualities of basic science—not of technology, but of basic science—that I think a citizen in a scientific society should be shown over and over until he begins to feel them for himself. One quality I have in mind is the excitement of science; another is the incompleteness of science.

To say that basic science is exciting may sound like a contradiction. We are used to the really spectacular excitements of the engineers with their radar and rockets, and the life-and-death excitements of the doctors—the biological engineers—with their white coats. By contrast, the intellectual excitement of a man sitting over a microscope in a university basement, tracking down a clue, may seem pretty tame. But I would remind you that there are intellectual excitements that are not tame at all and that we remember all our lives. One is the thrill of following out a chain of reasoning.

Intellectual thrills in science are not something distant or alien, but something closely continuous with our everyday thinking. It is true that science is complex. This is because so many men have been building it up for so long. Nevertheless, every individual step in it is a little inference as simple as looking out at the weather and deciding whether or not to take a raincoat. When we look at a celebrated rocket engineer like Wernher von Braun, we see a man running a big complex organization and dealing with incredible horsepower. But when we look at a fundamental scientist like James Van Allen, the university professor whose tiny satellite equipment detected the radiation belts around the Earth, what we see is essentially a man stepping to the door of his planet to see how the temperature is outside.

What is essential in any science story is the little chains of everyday inference—the reasoning. It may surprise many people to know that the chain of new scientific reasoning in a whole research study is frequently less complex than an everyday business

continued on page 279

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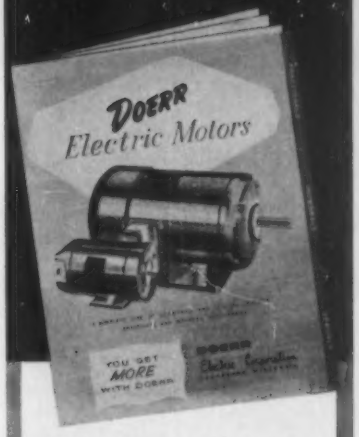

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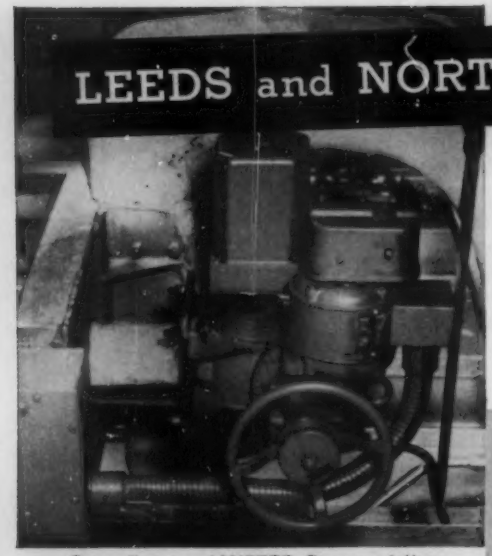

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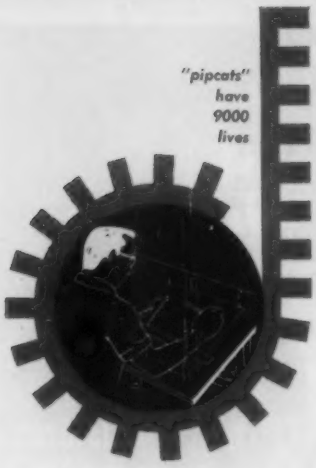

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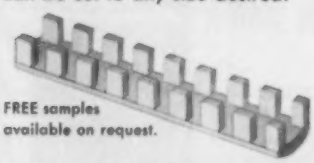

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decision or a crossword puzzle or a game of chess. It would have a salutary effect on our attitudes if for twenty-four hours we could cross out the words "science" and "scientist" wherever they appear, and put in their place the words "man reasoning." Even in the mathematical sciences, like physics, it is the reasoning that comes first, the equations second; and the equations will not save the theory if the reasoning is wrong. It cannot be said too often that science is not mathematics, but reasoning; not equipment, but inquiry.

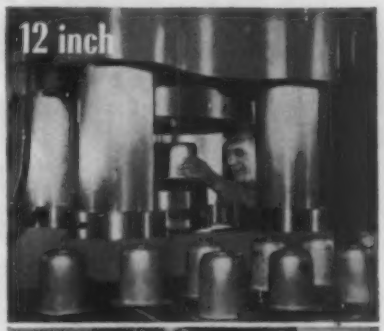
The master at demonstrating reasoning to a mass audience was Conan Doyle. It would not be far wrong to think of every science story as his kind of story, with its puzzles and its suspense, its false leads and frayed tempers, and its brilliant Sherlock Holmeses and its half-brilliant Inspector Lestrades and its admiring Doctor Watsons. It is interesting to remember that Galileo used a very similar group of characters to explain his theories.

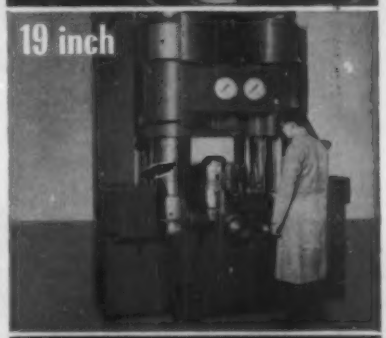
All science has gaps in it. The most familiar are the inevitable small gaps, the data that one could still go on taking, the unexamined minor assumptions or the unresolved questions. Most of these do not bother us, because we realize that a scientific age is an age of tentative conclusions and working rules that may well have to be changed later. Yet it is important for us to emphasize this incompleteness, especially to the young, because they have hopes and aspirations and they want an open-ended story, with something left for them to do when they finally take our places.

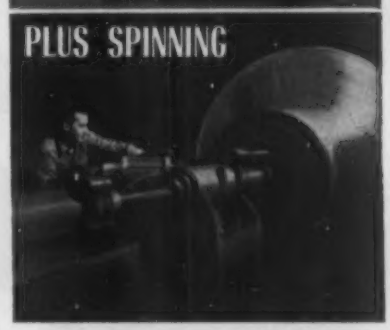
What is not so often realized is that science is incomplete in more serious ways, with gaps that scientists themselves, tied to their own narrow specialties, hardly realize the existence of. In some ways, for all its diversity, science is narrower now than it has ever been before. Few of the men who work on photosynthesis know anything about physics; few of the men who work on nervous tissue know any organic chemistry; few of the men who work on the brain have any understanding of the mind. There are exceptions. An Enrico Fermi or Edward Teller or Harold Urey can work on stars or nuclei or molecules just as his fancy strikes him. A John von

continued on page 281

HYDROFORMING . . .







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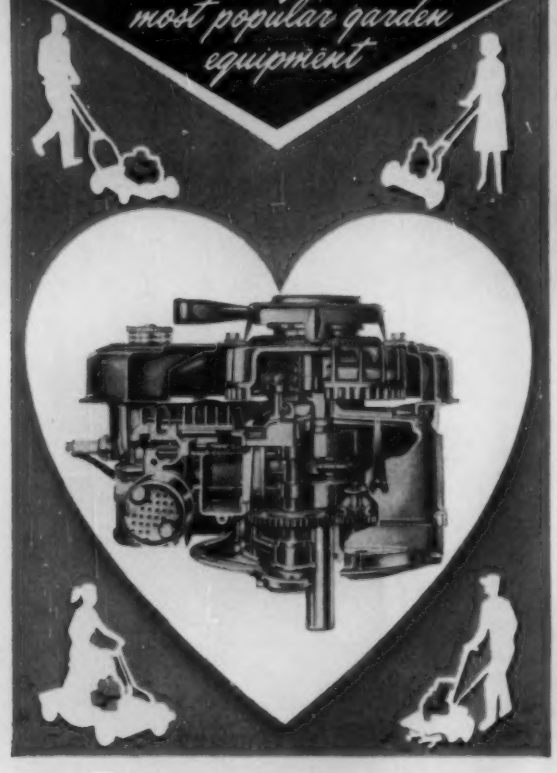

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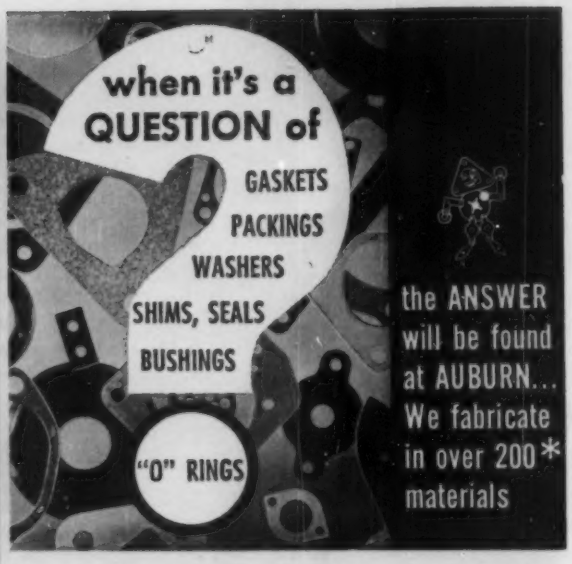

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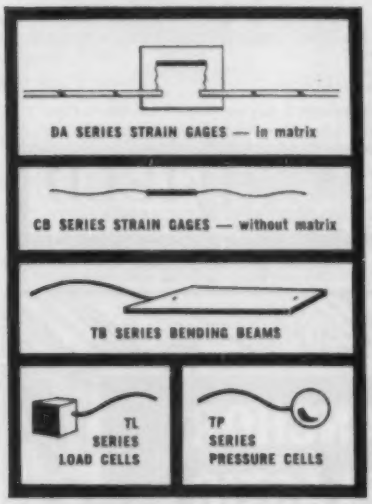
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Neumann can work on quantum mechanics as well as the theory of games. A Percy Bridgman can work on solids as well as logic. But for every such man, there are hundreds who spend their lives repeating the kind of experiments they did for their doctor's degree.

Even the intellectual leaders are blind to some fields. For over a century, some of the greatest physicists, Young and Maxwell and Helmholtz and Schrodinger, thought it of the greatest importance to study human visual perception. Today, I daresay not one of the twenty leading physicists in this country would have even a casual interest in this subject. Likewise, interest in the philosophy of physics has dropped almost to zero among the bright young men; yet this field may simply be waiting for a new Ernst Mach who will stir it up and pave the way for another revolution like relativity. And we have all noticed such blind spots in the more technical fields, where it has suddenly been discovered, for instance, how badly everyone has been neglecting oceanography, an area perhaps of central importance for our future food and resources.

I think these gaps cry out for reviewers and critics broadly trained and broadly read, who are competent to see what the neglected areas are and to encourage the young to go into them. A balanced and vigorous science requires a balanced and vigorous criticism. Science, like war, is too important to be left to the scientists. Intelligent outside evaluation is good for a department, it is good for a university, and it would be good for science itself. The incompleteness of science is a challenge to great criticism.

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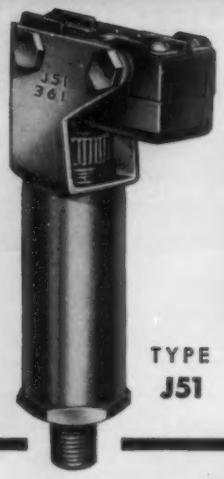

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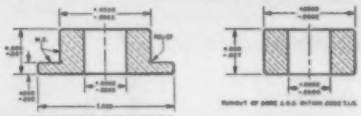

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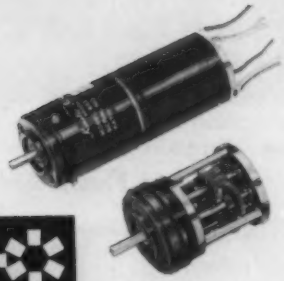

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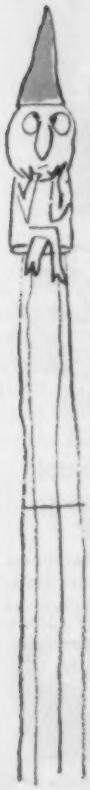

Have you stopped learning?

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Everybody's "da"-ing it

Sputnik's beep and a space-dog's bark startled Americans into studying sciences and the Russian language. Adult education and company-sponsored classes in both have bloomed all over the country, and highschools and colleges are offering survey courses. Everywhere the cry is, "Russian is so difficult!"

It seems that way to most of us because we're not language-conscious, as are most Europeans. But, according to Dimitri A. Nimidoff, a McGraw-Hill translator, this is not true. He insists that English is far harder for a Russian to learn, and that 75% of Russian scientists "write, read and speak English freely, as against some 3% of Americans who understand Russian"—and five-sixths of the latter are of European extraction. My own observation is that both of his percentages are high. Less than half the Russian scientists and engineers with whom I have talked can speak English, although a high percentage know a few technical words and phrases. Many youngsters of 8 to 12 know a few halting sentences. Obviously, the latter are being taught in school. But the former?

In contrast to the American "Johnny," who cannot read, Petrov can—and does. That's where the adult gets his English—from reading technical books and articles (particularly the latter) in English. Again and again, an engineer or scientist corrected my girl interpreter when she went wrong on a technical term—but in most cases he or she (30% of Russian engineers are women) could not talk English beyond those terms. The answer lies in the extensive reading of technical English the Russians do and in the fact that the government offset-prints and distributes 3000 copies of each issue of major American technical magazines. Russian engineers could talk with me of articles we had published just six weeks earlier, although PRODUCT ENGINEERING at that time was not sent to Russia. Copies were obviously picked up in Western Europe and rushed in for copying. Abstracts and full translations of the article into Russian come later.

HOW HARD IS RUSSIAN?

Russian must originally have been a relatively limited language, because

continued on page 285

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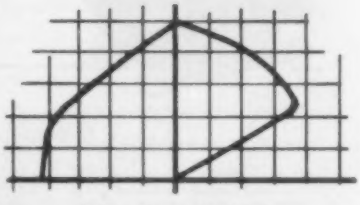

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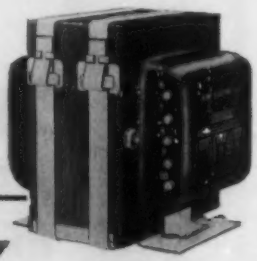
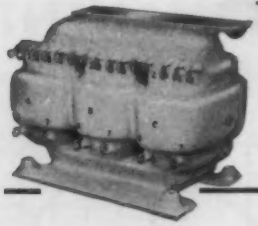
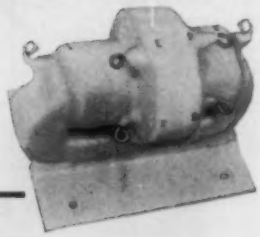




T-34671
VA: 705, weight: 4¼ lbs.
165°C rise, 125°C ambient
12 KV test at 30,000 feet



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VA: 47.8, weight: 14 ounces
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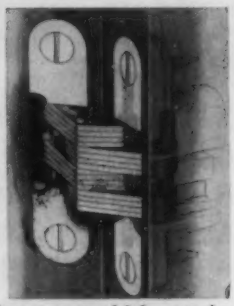

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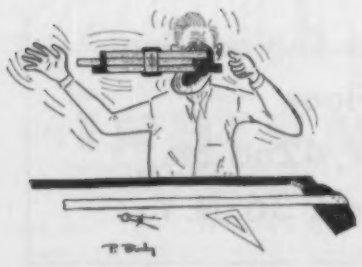
so many of its words mean a variety of things, and so many others are taken directly from French (once the Court language), German and English. As examples of the first, *oolitza* means both "outside" and "street," *masla* is butter, grease and oil. Differently spelled and accented, "professor," "restaurant" and "officer" are regular Russian words. A West Coast engineer with whom I talked agrees with this, says that in three years he's learned to translate Russian technical articles, starting from scratch, because of similarities in words.

The Russian alphabet is taken from the Greek and Latin ones, consists of 32 characters, each of which has only one sound. This is a tremendous advantage for the English student of Russian, which his opposite number does not have. A Russian, for example, will pronounce "knife" as "kaneefa," and cannot understand why we have letters we do not pronounce. *Through* and *tough* are impossible to him. Some Russian letters represent multiple English sounds (one is *sh-ch*!) and two of the characters merely indicate that the preceding consonant is lengthened or elided in pronunciation. Further, there are no elaborate tenses—just future, present and past. But Russian makes up for these simplicities—at least in my mind, with six cases for nouns and adjectives; gender and number for everything; numbers from one to five singular, and above that plural; and several other cute little tricks that leave my mind reeling.

If you go into it, prepare to dig and to study, study, study. Of several dozen Americans I know who began learning the language, only two or three can order a meal in Moscow. And if you can't order, you don't eat—the waiters and waitresses haven't learned English either. —EJT



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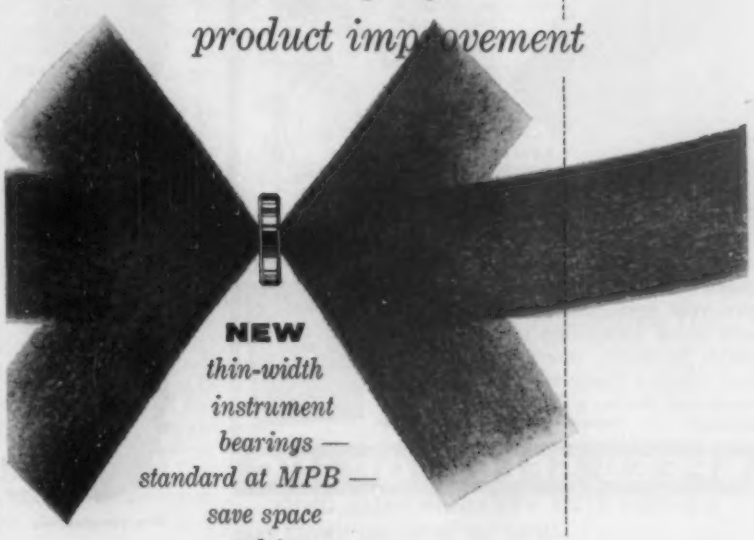

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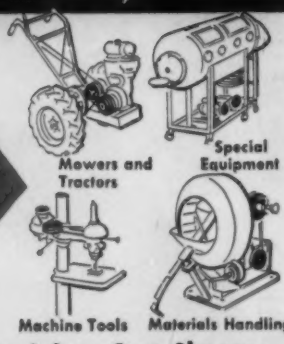

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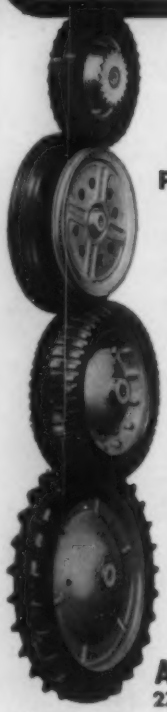

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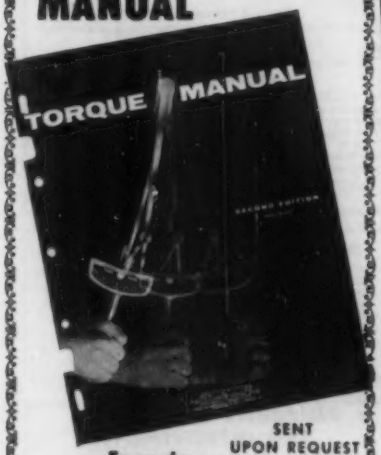

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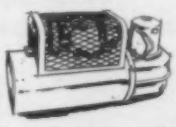

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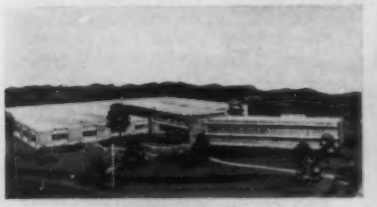

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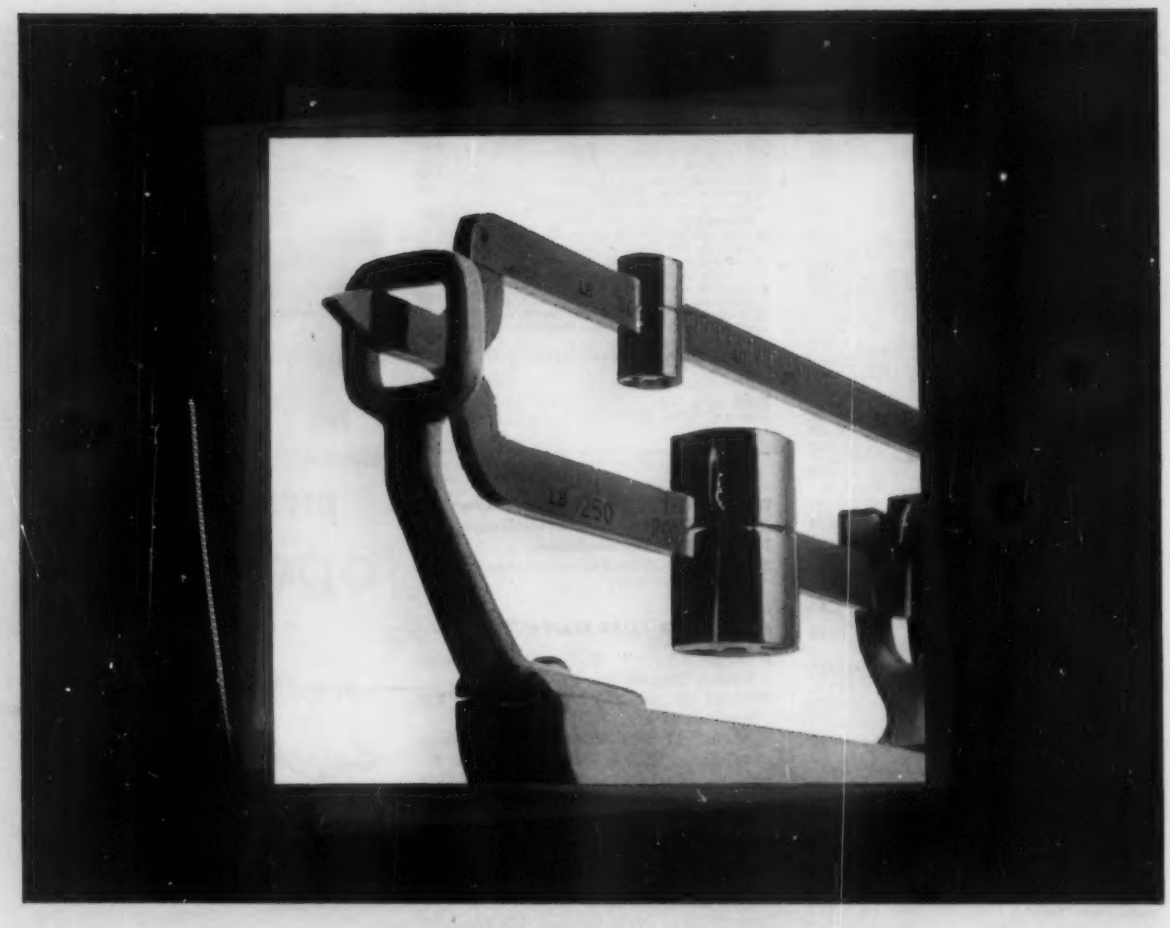

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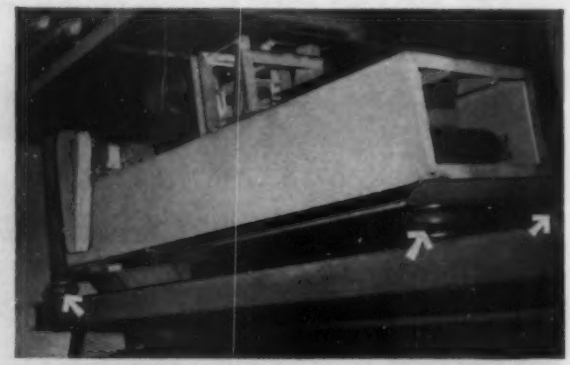

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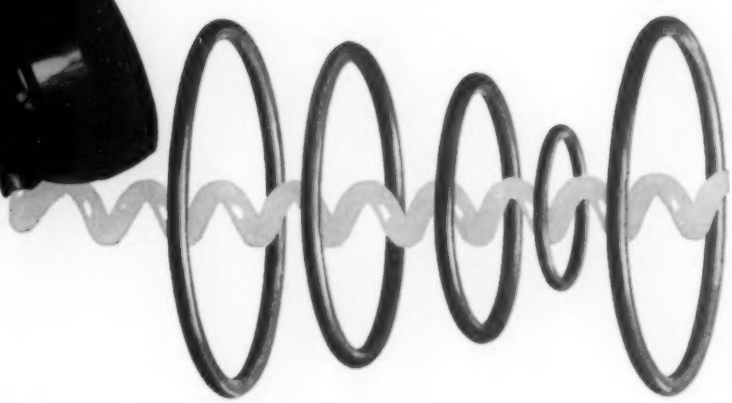

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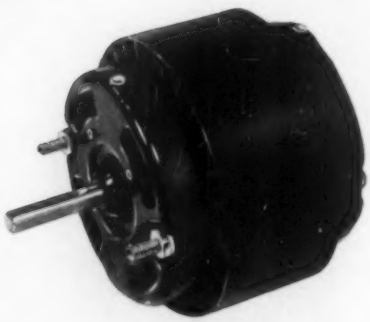

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